Modelling the computerised clinical consultations; a multi-channel video study

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A thesis submitted in partial fulfillment of the requirements of Kingston University for the degree of Doctor of Philosophy

Faculty of Computing, Information Systems and Mathematics
Kingston University London

July 2011

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Abstract

This study aims to understand the use of a computer during GP consultations and to enable the development of EPR systems which are easier to review, enter data into, use to take action, and is more sensitive to the clinical context.

This thesis reports the development of a multi-channel video and data capture toolkit, the ALFA (Activity Log File Aggregation) because existing observation techniques have limitations. None of the existing tools are designed to assess human-computer interaction in the context of the clinical consultation, where the social interaction is the prime focus. The ALFA tool-kit has been used to observe and study 163 live primary care consultations supported by computer systems with four different designs. A detailed analysis of consultation interactions was then performed focusing on doctor-patient communication and the integration of the computer into the consultation workflow. The data collection elements of the ALFA supported recording of consultation activities by providing rating techniques attuned with the characteristics of those interactions. The Log File Aggregation (LFA) component of the ALFA toolkit aggregated those multitudes of data files into a single navigable output that can be studied both quantitatively and qualitatively. A set of Unified Modelling Language (UML) sequence diagrams were then created as they could be used by software engineers to develop better systems.

This research proposes a framework with three elements to analyse the computerised clinical consultation; (1) the overview of the context within which the consultation was carried out, (2) time taken to perform key consultation tasks and (3) the process used. Traditional analysis with its emphasis on the technology often misses crucial features of the complex work environments in which the technology is implemented. Direct observation could inform software designers in developing systems that are more readily integrated into clinical workflow. Direct observation of the consultation, using the ALFA toolkit is acceptable to patients; captures the context of the consultation the precise timing and duration of key tasks; and produces an output a software engineer can understand. ALFA offers a range of possibilities for research in the consulting room. The computer should be considered as an active element of the consultation; room layout and consultation models should let the computer in, while software engineers take in the capacity to sustain patient centred social interactions as a core facet of their design agenda.

Summary of Findings

Background

The computer is an essential element for primary care delivery. Computer use has enhanced the effectiveness of consultation tasks by improving the completeness of medical records, accuracy of prescribing, patient safety, and also increasingly supporting chronic disease management tasks. As the medical record has become more structured the focus of consultations has shifted towards biomedicine. Inadvertently, Electronic Medical Record (EPR) systems which probably set out to be neutral recorders of clinical problems have become agents for framing problems in biomedical terms. This is despite the fact that most models of the consultation stress the importance of the social and psychological facets of disease and the importance of working in a patient centred way. A trade-off between patient-centred care and maintaining a comprehensive and up-to-date medical record exists.

Computer use may introduce unexpected changes to the consultation workflow. Clinicians may get cognitively overloaded as a result of the information demands or interruptions coming from the computer. This could influence the clinician-patient interactions, result in episodes of suboptimal computer use or change the direction of the consultation. There is a dearth of research aimed at assessing the direct influence of the computer on the interactions between doctor and patient. There is also lack of tools and rational approaches to validate the selection of technology or to inform the design, development and evaluation of clinical information systems.

Objectives

This research aimed to develop a consultation observation approach to understand the use of computer during a consultation and to measure the influence of different EPR system features on the consultation process.

Method

The study design has been formulated based on the understanding gained by studying the limitations of existing methods. There are four work-pages associated with the research method; (1) method to display multi-channel video of the consultation, (2) code and measure activities including computer use and verbal interactions, (3) aggregate multiple observations into a single navigable output and (4) produce an output interpretable by software developers. They are further supported by a set of theoretical frameworks developed to interpret the consultation observations without losing the associated contextual, clinical, social and technical attributes.

Results

The interactions observed were extremely complex and indicated how the computer whilst not the primary focus of the clinician is often a distracting informant. This study reports a low refusal rate in terms of the patient participation to a multi-channel video study; only 7% patients declined to participate.

Consultation length: The mean duration of a consultation is 11:49 minutes. There is no significant difference of consultation length associated with the EPR brand. Consultations with patients older than 40 years are significantly longer (p=0.006) than those for younger patients; this difference is nearly two minutes. The time where both doctor and patient are in the consultation room is about 88% of the entire consultation length. There is about 5% of the consultation, where doctors prepare

for the consultation before inviting the patient in, and the remaining 7% is spent interacting with the EPR system at the end. Examinations occurred in nearly three quarters of the consultations (73.6%), taking about 12% of the total consultation time.

Patient calling-in method: Calling-in could take nearly 6% of the greater consultation. Physically collecting the patients is the slowest taking nearly 7% of the greater consultation time.

Consultation room layout: A combination of the physical layout of the room and the doctor's actions determined the extent to which patients might view and interact with their computer record. The commonest room layout (62.5%) had the patient in the doctor controlled semi-inclusive position where they could not naturally observe the content of their EPR without changing the seating position or clinician turning the computer screen. Clinicians spend more time ($p<0.001$) looking at the computer screen when patient is seated in an inclusive setup. The amount of eye contacts is higher in patient controlled layouts, while situations where both doctor and patient are looking at the screen are more frequent in the inclusive setup.

Interruptions during the consultation: Interruptions were a standard part of the consultation for most GPs (27.6%), some had multiple interruptions (3.1%). A doctor leaving the room was (12.3%) also common. Telephone calls doctors received or made during consultations were the most frequent interruption.

Accompanied patients: More than quarter (27%) of the consultations had an additional person other than the patient. When the patient is accompanied, the mean duration of computer use within the core consultation was 29%. In the un-accompanied category this is 37.16%; a significantly higher proportion ($p=0.003$).

Consultation initiator: EPR systems initiated 7.4% of the consultations while patients were responsible for about a quarter (24.5%). Patients verbally interacted more and doctors spent significantly longer time ($p=0.006$) reviewing information available in the EPR when consultations were initiated by patients.

Doctor-patient-computer interactions: An important share of the core consultation is dedicated to direct doctor-patient interactions; where the doctor assigned his or her complete attention to the patient, physically turning away from the computer screen. This is about 45% of the greater consultation. Doctors engage in computer use with no interactions with patients for quarter of the consultation (24.78%); this is approximately three minutes. There is another 15% of the consultation time where doctors interact with the computer while interacting with their patients.

Doctor-computer interactions-overall: Doctors spend around 40% of the entire consultation, interacting with the EPR system. This represents 4:35 minutes of an average length consultation. Computer use is normally distributed across the study sample. The amount of computer use appears to be not significantly influenced by the doctor's age, gender or number of years they have been practicing as a GP.

Doctor-computer interactions-distribution: Doctors allocate about one third (35%) of the core consultation for computer use, while it takes up more than half of the initial consultation (59.3%) and almost three quarters (74.6%) of the final marginal consultation. Doctors spend just over a third of the time on (37%) viewing the information without making any changes to the EPR, more than half of that (21%) is looking at the normal consultation interface. Half of the computer use time represents doctors actions aimed at recording data into the EPR and taking actions (31% and 19%).

Doctor-computer interactions-categories: The proportion of the consultation time doctors spend reviewing the information and for recording data is influenced by the brand of EPR system they use. Younger doctors spend considerably less time looking at the default consultation view without performing a specific activity. The majority of the information reviewing tasks occurred in the first quarter of the consultation, data recording tasks increases towards the third quartile of the core consultation while narrative data entry continuously increased with the consultation's progression. Doctors performed taking actions type tasks mostly in the second half of the core consultation.

Doctor-computer interactions-influence of the EPR system: There are significant differences associated with the number of coded data entry episodes amongst the four systems. Doctors interacting with EPR systems with problem oriented data recording strategies coded more data. There are also significant differences related to the time doctors spent initiating coded and BP data entry interfaces, entering coded data, activating lists of past prescriptions and interacting with interfaces for creating prescriptions. Majority of these differences are linked with the interface structures and workflow designs.

Conclusions

To use the computer effectively requires a change in consulting room layout so that the patient can easily see the screen. Designers need to recognise that the computer is used for a significant and a consistent proportion of the consultation, and if it is inefficient less data is recorded and forcing data entry affects the quality of the medical record. EPR systems also need to be able to cope with interruptions, consultations where the patient is accompanied and acknowledge the contingent nature of consulting.

Acknowledgement

I would like to express my gratitude to all those who gave me the possibility to complete this thesis. I am greatly indebted to all the patients and doctors who took part in this study, for their time and kind cooperation, without whom this thesis and the associated findings would not have materialised.

In the early days it was the faith placed in me by Mrs. Anne Rapley, as the supervisor for my undergraduate project, who recognised according to her words-the 'research animal' inside me, which spurred me to become a researcher. I am enormously appreciative of the support received from her.

I am enormously grateful to Dr. Simon de Lusignan, who shaped me into a researcher, sponsored my studentship, and supported me immeasurably as a supervisor, colleague and a teacher. I am ever indebted for the intellectual guidance and knowledge received from him. He exposed me to the work of many international research groups, individuals, conferences and guided me immensely to build up a publication record from the very beginning.

Copious thanks are due to my director of studies, Dr. Beryl Jones for supporting all aspects of my research, and especially for taking care of all the organisational demands associated with this research. I would like to thank Dr. Penny Bidgood for all the advices pertaining to the statistical analysis, and for regularly allowing me to have tutorials with her at short notice. I am indebted to Prof. Tim Ellis, who as the dean of the faculty and as a supervisor, constantly and invaluable guided me and for often being the voice of reason.

Enormous thanks to Dr. Aumran Tahir and Dr. Imran Rafi for introducing me to the majority of the doctors that took part in this study. Their support throughout the simulated and real-life consultation recording sessions is invaluable. I am indebted to all my former colleagues at St George's University of London, with who I spent nearly half a decade. Their support was invaluable to enabling me to multi-task as a PhD student, Research Assistant and an academic tutor. I am grateful for the consistent support I received from Mrs. Katherine Piggott and for always being there to discuss any concerns. I also owe a debt of gratitude to my academic and research colleagues at Kingston University for their unwavering support and encouragement.

And finally and certainly I am thankful to my parents, my sister and my brother-in-law for their encouragement, moral support and for 'equipping' me to be a productive human. I am enormously grateful to my wife Sameera for her continued support, the never ending encouragements and love I received through my protracted studentship. Without her this research would not have been feasible. I am also thankful to my little daughter Viyara, for keeping me smiling.

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Glossary of abbreviations, acronyms and terms

ALFA	Activity log File Aggregation toolkit
BAT	Bilateral Actor Time
BP	Blood Pressure
Dr	Doctor
EMIS	Egton Medical Information System
EPRS	Electronic Patient Record System
GP	General Practitioner
LFA	log File Aggregation
LV or EMIS LV	LV clinical system by 'EMIS' software manufacturer
MR	Medical Record
ODC	Observational Data Capture
PC or **Comp**	Computer
PCS or **EMIS PCS**	PCS clinical system by 'EMIS' software manufacturer
Pt	Patient
Read	Clinical coding system by that name
Surgery, Practice or **HC**	General Practice surgery premises
Synergy or **iSoft Synergy**	Synergy clinical system by 'iSoft' software manufacturer
UAR	User Action Recorder
UTAT	Uninterrupted Three Actor Time
VAR	Voice Activity Recorder
Vision or **INPS Vision**	Vision clinical system by 'In Practice' software manufacturer
X	Mean
M	Median
SD	Standard Deviation
IQR	Inter Quartile Range (difference between 25th and 75th percentiles)
Min	Minimum value
Max	Maximum value
LSD	Least Significant Difference
Greater consultation	This is the duration of the consultation which includes all the interactions starting from the selection of the patient's medical record from the appointment list, up to the moment when the updated record is closed. The greater consultation contains three parts: the initial marginal consultation, the core consultation, and the final marginal consultations.
Core consultation	The duration that patient is inside the consulting room
Initial marginal consultation	The period between the selection of the patient's medical record and the patient's arrival

Final marginal consultation	The period between the patient's departure and closing of the patient's medical record
Three actor time	Situations where all three elements; the doctor, the patient and the computer are in an engageable status
Bilateral actor time	Situations where only two out of the possible three elements are in an engageable status; i.e. either the doctor or the patient has left the consultation room
Triadic interactions	Situations where the doctor, the patient and the computer are involved or usefully taking part in interactions
Screen sharing	Doctor inviting the patient to view information on the screen
Overhead interactions	Unplanned interactions interruptions that are not part of the intended computer use
Singleton interactions	Interactions that generally occur only once during a consultation; e.g. blood pressure recording
Continuous interactions	Interactions that could occur throughout the consultation duration, e.g. eye contact
Episodic interactions	Interactions that are distinctive and occur in blocks, and are predictable to a certain extent; e.g. coded data entry
Picking list	List of items offered as a drop down list after searching for a clinical code
Encounter reviewing	Going through data from past consultations and other health encounters
Accompanied patients	Patients who arrived with their family members or friends
Calling-in method	Approach adopted to invite the patient into the consultation
Parts of the consultation	Different sections of the consultation duration defined based on the patient's presence or the activation of the patient's medical record by the GP
Global consultation time	The total duration of recorded consultations, from all 163 sessions.

CHAPTER 1

Introduction and rationale for the research

1.1 An introduction to the thesis

1.1.1 Background

The general practice consultation is the core component of delivery of primary healthcare. An effective primary care clinician is aware of the biomedical, psychological and social facets of the patient's problem, addresses them in a sensitive manner and adopts a patient-centred style. Traditionally this was a one-to-one interaction between GP and patient; however, the computer has progressively become a third actor in the consultation.

My initial research interest was the quality assurance of routinely collected primary care data used to support research and quality improvement. However, my observations of their variation between systems and the extent to which they influence data recording led me to explore the impact of the computer on the consultation. Consequently, this research explores the way in which EPR system differences affect their use within the consultation and how they may possibly lead to different outcomes.

The improved use of information technology is a core strategic factor in enhancing the healthcare delivery. Electronic Patient Record (EPR) systems developed to be used at the point of care vary greatly in their underlying design principles. They are dissimilar in their interface designs and functionality and inevitably have dissimilar impacts on the consultation. The consultation contains complex social interactions which have subtle associations with the patient's experience and satisfaction. It is plausible that the introduction of the EPR system will alter these.

However, there is a dearth of tools and rational approaches capable of detailing the way in which computers are used during the consultation. This thesis contrasts different design features of current EPR systems and their impact on the consultation.

1.1.2 Scope of this thesis

This research has been conducted to provide a more rational basis for improving EPR system development. The literature review describes the complexity of the doctor-patient relationship, the context in which any EPR system might be used. It also reports the organic development of the medical record and the dearth of an 'objectivist' approach to its evaluation (Friedman and Wyatt,.2005). In the absence of an established method to make precise comparisons between systems a new approach was needed.

A new multi-channel video recording tool-kit (ALFA tool-kit) was developed to introduce a systematic approach for describing the impact of the computer on the consultation. Using the ALFA tool-kit, I then studied 167 clinical consultations, studying the content of computer assisted consultations and comparing the influence of EPR system designs. The outputs from this research can be used to inform the design, development and evaluation of EPR systems to support general practice consultations.

1.2 Introduction to the research domain

1.2.1 Primary care

Primary care is the setting for delivering the first contact medical care and also the continuous, comprehensive and coordinated health care provider of the population (MRC,n.d). It is the place within the health system, where most medical decisions are made about the widest possible spectrum of health problems. Kerr White used the term *primary care* in 1961 to describe a frontline health service that can address a range of health problems in the population (White et al.,1961). One of the initial definitions for primary care, proposed in 1979 by the Institute of Medicine (IOM) used five attributes; accessible, comprehensive, coordinated, continuous and accountable (Peterson,1980). Subsequently this definition was updated in 1996 to encompass the following features; multidimensional and integrated nature of the care delivery; the family and community orientation; and the notion of sustained partnership with the patient. A more recent European definition (Allen et al,2002) includes heuristic decision making, a holistic approach and patient-centred delivery.

Starfield (1992) describes how primary care is distinguished from other levels of health service by the clinical characteristics of the problems it deals with; their variety and the commonness, and also by its accessibility for the patients. The World Health Organization's Alma-Ata declaration of 1978 recognises that primary care is key to delivering 'health for all' (PAHO,n.d).

Primary care has its own scientific body of knowledge. Primary care professions deliver health care using a patient-centred consulting style. The decision making process has to consider the individual's ideas, concerns and expectations (Pendelton et al.,1984) as well as the implication to the health gains of the population. The characteristics of primary care and its care process also have to reflect the changes in the environment within which it operates; for instance, the policy decisions, changes of public services, cultural trends and societal factors (Levenstein et al.,1986).

More recently the introduction of pay for performance in chronic disease management has changed primary care EPR systems and clinicians' willingness to record relevant data.

1.2.2 Informatics, health informatics and primary care informatics

Dreyfus coined the term "*informatique*" in 1962 to broadly represent the use of computers to process and store information. In 1983, Gorn used it to describe the combination of computer science and the information science. Efforts to automate the information processing, work flow and synthesis of new knowledge were represented as 'to informate' by Zuboff (1988). Now it is recognised as the multidisciplinary study of the "representation, processing, and communication of information" together with its computational, cognitive and social aspects; often within the context of another discipline (Feather and Sturges,2003). The term 'Informatics' is often used compounded with the name of another scientific field; for example health informatics, biomedical informatics.

The health informatics (HI) domain encompasses the knowledge, skills and tools that support the delivery of health care and promotion of health (Sullivan, 2001; Musen and Bemmel, 2002) . The discipline of Health Informatics represents the interaction between the fields of information science, information technology, medicine and health care. It includes not only associated information systems but also medical terminologies, clinical guidelines and standards.

The focus of health informatics has shifted from providing more searchable electronic substitution for paper record systems to more integrated systems capable of monitoring quality, facilitating research and possible information support (Conrick, 2006).

Primary care informatics has developed as a subspecialty of health informatics. Primary care has its own heuristic decision making process(Allen et al., 2002). Routinely collected primary care patient data are widely used for; (1) health services planning and research (2) to understand the clinical epidemiology, (3) guidelines development, (4) quality improvement and (5) service monitoring. Its emergence as a scientific discipline has been increasing with the availability of large amount of routinely collected data for secondary uses (de Lusignan, 2003).

1.2.3 Primary care consultation

The consultation is the functional unit that delivers primary care. It is an encounter between doctor and patient. This is the setting where problem definition takes place, and outcomes are defined into which both the doctor and the patient bring their own personal, societal and technical contributions (Freeman et al., 2003).

Balint describes the doctor, the patient and the problem under consideration (or the illness) as the fundamental constituents of the consultation (Balint,1970). In Leeuwenhorst's definition of general practice, the consultation is understood as the setting where the doctor considers the physical, social and psychological factors related to the patient's health and illness and decisions about their management are made (Leeuwenhorst Group,1970). Oluesen et al. (2000) likens a sickness episode to a scene in a film, and a consultation to a single frame. The Health belief model proposes that patients' need for help or health-care seeking behaviour as the originators for the consultation (Becker, 1974).

The uniqueness of the general practitioner is linked to the doctor's propensity to recognise the patient's illness not only based on biomedical factors but also considering a social and psychological dimension. The new European definition of General Practice (Allen et al., 2002), through its six core competencies reveals a number of the qualities that define the general practitioner as a unique health care professional.

Core competencies	Characteristics
1. Primary care management	First and continuing contact, unlimited access, all health problems, interfacing between generalist and specialist care, managing change
2. Person centred case	Person centred approach, longitudinal continuity, developing trust, shared decision making and responsibility
3. Specific problem solving skills	Wide spectrum of diseases, awareness of incidence and prevalence of illness, all stage of illness, tolerating uncertainty and unpredictable developments
4. Comprehensive approach	Acute and chronic, co-and multi-morbidity. health promotion, prevention, early intervention. Listening and supportiveness
5. Community orientation	Reconciling individual health needs with those of the community, combined care with secondary and tertiary care.
6. Holistic approach	Biomedical, psychological, social, cultural and existential dimensions. Physical and mental well being.

Table 1.1: New European definition of General Practice

1.3 Rationale and background to the research

General practice electronic patient record systems are more effective in contributing to preventative, screening and the biomedical aspects of the diseases than supporting the complex interaction discussed in the section above. There is a gap between what the computer does well and what is needed to support a 'good consultation'. This thesis seeks to address this gap by (1) gaining insight into the time taken and how information technology is used in consultation; (2) contrasting the time and capturing the workflow to complete common clinical tasks and (3) modelling, given the complexity of a consultation, in a way that can be used by software engineers to develop better EPR systems.

1.3.1 Role of Electronic Patient Record (EPR) systems within the consultation

In 2006 there were nearly 300 million GP consultations in England (NHS-IC,2007). It is estimated that the number of consultations undertaken by a GP per year is approximately 7500 (OHE,2004). The average number of consultations per person per year was reported as five in 2002.

Information and Communication Technology (ICT) is increasingly used to support health care delivery and management (France, 2006; Haux, 2006)˙ General practitioners are now maintaining comprehensive electronic health records of the patients under their care (Ash, 2005). During the consultation computers support a wide range of tasks (Morris et al., 2005; Preece, 2000); they can display past medical history, test results, correspondence received from secondary care. They can be used to make test requests and book online appointments for further care. They can also provide knowledge support for decision making. These EPR systems also provide reminders and prompts to alert practitioners about drug interactions, allergies, medication reviews and missing data items.

1.3.2 Uniqueness of the EPR systems' operating environment

The context within which the EPR system operates is distinctive compared to other information system applications. In a consultation the patient is the prime focus of the GP; rather than the computer. The exchanges between the doctor and the patient, which originally used to be a pure one-to-one encounter, are now mediated by an EPR system.

In any consultation the process is an integral part of the outcome and determines the encounter's success. The doctor's ability to add a diagnostic label to the medical record or generate a prescription alone would not reflect a positive outcome; the way in which the doctor reaches an end point incorporating the patient's ideas, concerns and expectations is just as important.

1.3.3 Organic development of primary care EPR systems in the UK

UK general practice was an early adopter of EPR systems. Computerisation initiatives can be traced back to the mid-1970s. Most of the EPR systems were developed organically, rather than based on design. They have evolved in isolation from each other and been focused on the needs of their users. The early systems were designed by enthusiasts, aimed at automating routinely performed labour-intensive tasks. Subsequent to widespread computerisation of the primary care, the health services started imposing standards on the system suppliers and required standardised functions (DOH,2001). This led to the replacement of the large number of small EPR system suppliers by a small number of major suppliers. Often larger manufacturers took over the smaller developers together with their existing products and merged several of them to form new brands.

Supplier name	Clinical system brands
Chime UCL	GP CARE
ECL Medical	Genprac
EMIS	GV, LV, PCS
GPASS	GPASS, New GPASS
Healthysoftware	Crosscare
INPS	Vision, Vamp Medical, GP+, Surgery Manager
Microtest	Practice Manager 2
Seetec	GP Professional v3, GP Professional 4, Enterprise
The Phoenix Partnership	System One
iSOFT	Synergy, Premiere, Synergy Enterprise, Ganymede, GP Manager v2, GP Manager v3, HMC, MicroDoc, System 7, Visual Phoenix, Pennine Phoenix, Med System 5, Meditel 6000, GRSA, Geni, GCS, Premiere Text, , AMC 2000, MCS 2000, AmSys, Update PCS, Option Clinical System, Geminus, Medico, Superlink, GP Base, Mediscan, GP Records

Table 1.2: EPR system suppliers and different system brands introduced or acquired (NHS-CfH-GMS certification,2010;RCGP,2004;gpdata,2010)

Supplier name	Market share % (practices N = 8810)
EMIS	58.5
INPS	17.2
iSoft	14.5
Microtest	2.1
Phoenix Partnership	2.0
Protechnic Exeter	1.2
Seetec	1.0
Healthy Systems Software	0.4
The Computer Room	0.2
Chime UCL	0.1
Not computerised	2.8

Table 1.3: The EPR system suppliers and their market share in 2003 (RCGP,2004; PRIMIS,2009)

In 1988, a questionnaire-based study by Daniels and Coulter (1988) identified 40 different GP systems. Though there were over 100 systems mentioned in the DoH 1993 survey, it is believed that the number of commercial suppliers were around 50 (GMSC,1992). Table 1.1 shows some of the suppliers with their different GP clinical systems brand. The largest number of brands under iSoft is due to the number of acquisitions made by its precursor Torex. According to the PRIMIS+ supplier list (PRIMIS,2009) currently there are ten clinical system suppliers. EMIS dominates the market with their systems in more than half of the practices in UK; over 59% in England and 52.5% in UK. The combined market share of INPS and iSoft is more than 30%. The rest of the seven suppliers accounted for less than 10% of the total GP clinical system market. (Table 1.3)

1.3.4 Common functionality across EPR systems

EPR systems support tasks within the consultation and for practice management (e.g. appointment booking, report generation). The focus of this research is their in-consultation capabilities.

Two types of data are recorded in the EPR; coded data and free text data. Coded data entry is predominately done by supplying a search term to the system and selecting a suitable item from a list of matching code labels suggested in response. The codes suggested in this pick list are from a single nationally used code classification system designed to standardise the way the clinical summary information is recorded. These are known as Read codes. Availability of data entry forms or wizards is common to all systems to standardise and increase the amount of coded data captured.

The free text data entry only involves typing in the narrative. They are more useful in recording the patient story and allow better expression of feelings.

Common tasks of the EPR systems include acute and repeat prescriptions, test and referral requests are also common EPR related tasks. Some systems require linking these with an existing problem title, making the subsequent reviewing of the record easier. They can be arranged chronologically or based on the associated diagnostic problems.

All systems provide work management conveniences through appointment lists, diary events and calendar systems. There have been many attempts to include clinical decision support features in EPR systems. These could range from simple reminders, to knowledge-based articles covering drug, disease or clinical care pathway details. There are additional tools for querying information, generating statistics or summary data about the practice population through attached clinical databases and disease registers. Usually GPs do not interact with them during a consultation.

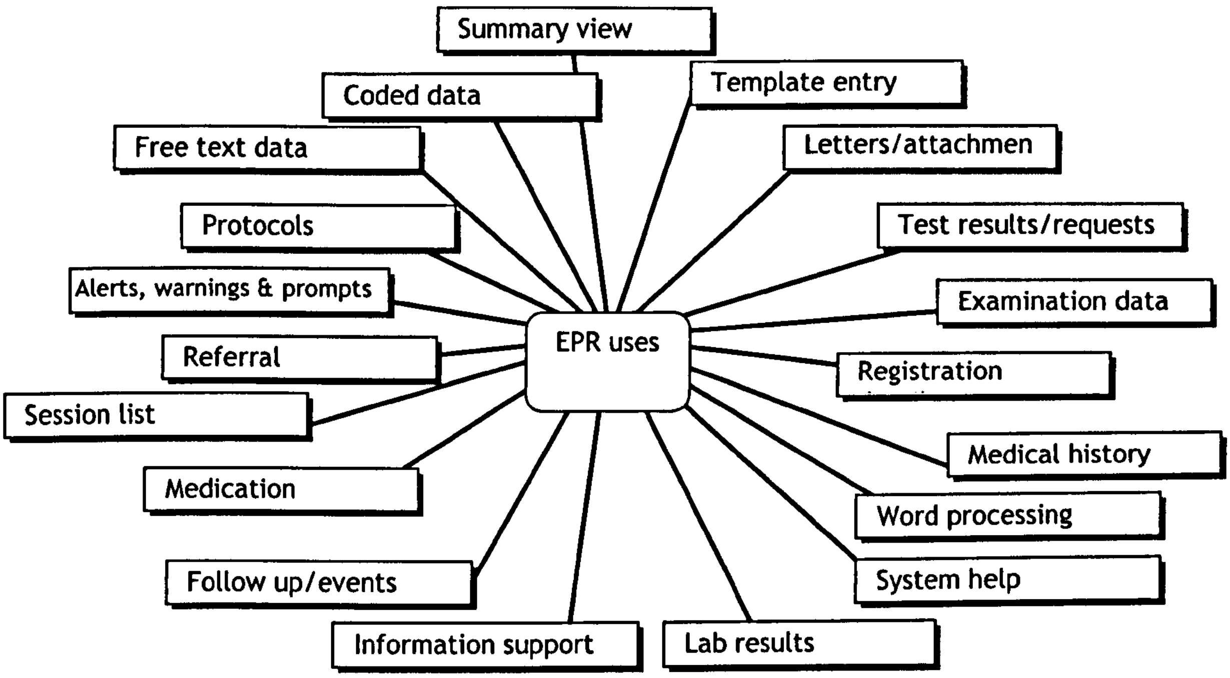

Figure 1.1: Objectives for in-consultation interactions with EPR systems

1.3.5 Implications of EPR system design on its use in the consultation

Although the EPR features are designed to support similar consultation tasks, the variations in the usability, functional features, usefulness for the intended tasks and the GP's level of awareness about the design features mean they are utilised in dissimilar ways. Consequently the impact they have on the consultation work flow may vary (Kushniruk et al,2006). It is important to recognise that these interactions with the computers are performed by busy clinicians, while involving themselves in a demanding social interaction with their patients. GPs have to make the clinical decisions and perform the necessary computer assisted tasks – navigate in the system, identify the most appropriate option, follow the sequence of interactions and so on, in the presence of a patient who came seeking his or her counsel. The GP might also be concerned about his or her progress within appointment list for the day or for reasons of time and work pressure may decide to allocate only a restricted amount of the time for these interactions.

The use of icons occupy less space, however may obscure the intended function. Their effectiveness relies on their visual distinctiveness, accurate representation of the appropriate concept and limiting the number of them displayed at one time (Stephanidis,2007) . Use of text links in contrast has the advantage of providing an explicit indication of the associated function. Despite having the same underlying coding system, design difference of the EPR systems lead to different coding practices, and dissimilarities in the associated doctor-computer interaction patterns. While the approach of linking coded and free text data introduces a structure to the data entry, and improves coded data recording levels, it introduces additional interaction with the risk of collecting increased number of less specific or needless codes. The use of data entry form streamlines the data collection, however this could be at the expense of non-verbal interactions or personalised verbal interactions with the patient. There is no systematic way of identifying the most favourable mechanism out of those for the doctor to interact with the computer.

Likewise the advantages of having sub windows by providing the ability to navigate between different functional areas need to be evaluated against the demands of the consultation. Considering the amount of time GPs get to interact with the computer, it may turn out that moving between different pages requires less concentration compared to navigating within an information rich, complex interface. These are merely example for the possible implications of the visual designs of the EPR interfaces could have on the consultation tasks. The actual patterns of GPs' use of the EPR features in the consultation, the tactics behind the selection of particular methods of interaction and their exact influences on the overall consultation remain unclear.

1.3.6 EPR systems to support values of the general practice consultation

There is a lack of understanding about the extent to which the current EPR system features positively or negatively influence the fundamental values underlying the general practice consultation. The capacity to develop less intrusive EPR system features may depend on the ability to evaluate their performance in the consultation. Identification of the cognitive effect of the EPR system designs, with precise nature of their influence on the consultation interactions could possibly enable the isolation of the usability issues, influence of the functional features and concerns about the interfacing skills. Such mechanisms would also have applications in EPR system selection, designing, development and simulations. This will also inform the selection of design principles and methodologies suitable for clinical consultations. More recent ventures are aiming at developing enterprise wide systems. These provide the opening to introduce improved systems, with greater emphasis on interoperability (Lopez et al,2007). They have advantages for data sharing, increased availability of information and patient safety. This provides prospects to recognise best features of the existing systems solutions, to use their underlying design principles more widely and to find alternatives for incompatible design aspects rationally.

The research base directly related to the impact of the technology on the consultation is limited. Most have looked into specific aspects, mostly social within the consultation or considered the computer as an object feature of the consultation environment. Consequently, there is a dearth of knowledge about the impact of the EPR design features. Furthermore, there is a need for evidence based on which improved information system solutions and theoretical frameworks for computer mediated consultations could be developed. And on the whole there is lack of understanding about the actual constituents of the computer mediated consultation interactions, their process flows, distribution within the consultation, possible variations and the impact of the technology on them. The increased awareness about the possible influences the EPR systems could have on the consultation can possibly transform the clinicians' point of view about them as information agents at their disposal to facilitate the consultation, and as a resource that can be shared with the patients. There is a clear need for effective techniques and an evidence base capable of recognising, exploring and developing strategies for balancing the best use of the EPR systems while sustaining the patient centred agenda of the primary care consultation.

1.4 The research motives

"IT experts are extremely good at linear, reductionist positive thinking, and not so good at constructing social solutions and appreciating other perspective. So there is an inherent mismatch between the mode of thinking required to develop robust social solutions and thinking required to develop robust technical solutions".
(Chapman, 2002)

Throughout a clinical consultation there is a constant demand to acknowledge and integrate two imperative and separate aspects of the presenting problem (Smith,1996) ; the psychosocial and biomedical. Maintaining a balance between those is crucial for a successful consultation. Medical training has recently introduced this standpoint to the clinical skills training (Coulehan and Block,2001). However, acquisition of those skills is complicated by the fact that the design principles of the clinical computer systems have been driven predominantly by a biomedical agenda. Maintaining a patient centred approach, and at the same time acknowledging two disparate dimensions of the presenting problem while multi-tasking with an increasingly biomedicine oriented computer system has contributed to make the consultation an intricate and multifaceted encounter. Gaining insight into all those dimensions are imperative in order to augment the skills of the doctor, motives for the information architecture and the enhancement of the consultation outcomes.

The sensitivity of the patient to the societal aspects of the consultation, and the doctors' recognition of its therapeutic facet has maintained the practice of medicine as a human science. Despite its scientific basis, this social outlook could probably defy the possibility of computerising the consultation in its entirety. The need is to identify the ways for balancing the best use of the computer with the fundamental values of the doctor-patient encounter.

'The Doctor' by Sir Samuel Fields, 1891. A Victorian time family physician courteously devoting his attention to the patient.

Doctor and patient

Ottery St Mary Health Centre, 1975; world's first paperless. The enthusiastic adoption of computer to support the consultation tasks, holding information for later use

Doctor, patient (and computer)

Modern day computer assisted consultation More demanding computer systems capturing data for wider use, and interfering with the subtle social interactions?

Doctor, (patient) and computer!

Figure 1.2: The story line; the objectives of the consultation and role of the computer

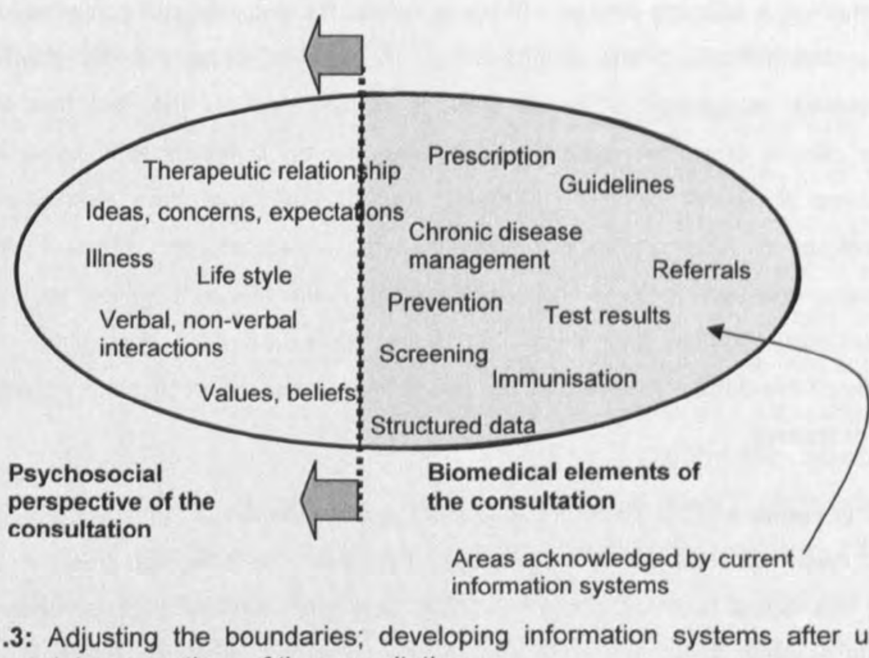

Figure 1.3: Adjusting the boundaries; developing information systems after understanding the biopsychosocial perspectives of the consultation

1.4.1 Research hypotheses, aims and objectives

The capabilities of the clinical systems in managing the biomedical information are proven as discussed in the earlier sections. Informaticians now need to direct their efforts more towards fine-tuning the participation of the information systems to maintaining the intrinsic worth expected from the consultation. The attempts for minimising the negative influence of the computer use on the consultation would benefit from fitting techniques for identifying and exploring its precise role. Influence of the information systems on consultation tasks is the principal phenomenon that has been the subject of this study. Therefore, this thesis presents the design, conduct and findings associated with the principal phenomenon, organised around the research question, hypotheses and aims as stated below.

Research question

How do different electronic patient record system design features influence the common consultation tasks in the computer assisted general practice consultation?

Research hypotheses

The following hypotheses along with others discovered in the course of this research have been tested.

Primary hypothesis: Multi-channel video based observation can assist in identifying the precise role of the computer within a general practice consultation and the influence of information system design features when performing common consultation tasks.

Sub-hypotheses;

Hs1. Use of multiple video channels and automated capturing of computer use data enable the observation of doctor-patient-computer interactions comprehensively

Hs2. Observational data coding techniques can be utilised to generate an analysable overview of doctor-patient verbal and non verbal interactions, and the integration of the computer

Hs3. There are contextual elements (factors associated with the environment within which the consultation is conducted) that can be influential in defining the duration and nature of computer use

Hs4. The type of the EPR assisted task; whether information reviewing, recording or taking actions and whether the tasks are performed before, during or after the patient's visit influence the computer use characteristics

Hs5. The proportion of computer use is not associated with the EPR system involved

Hs6. The quality of the common consultation tasks performed and the ability to support patient centeredness are influenced by the EPR system design features

Hs7. The time taken to perform and the process flow associated with the common consultation tasks are linked to the EPR system design features

Hs8. Process models of common consultation tasks can assist to establish associations between EPR system design features and the characteristics of common consultation tasks

Research aim

To differentiate the influence of electronic medical record system features on the common clinical tasks in the consultations to inform a rational choice and agenda for systems development.

Research objectives

1. To conduct a literature review to determine what is already known about the subject. Identifying the context within which the general practice consultations are conducted, its current standing and the progressive development of its significant constituents.
2. To develop a tool kit capable of precisely measuring the impact of the electronic patient record systems on the common consultation tasks.
3. To code the significant contextual components that influence the use of electronic medical record systems within the consultation
4. To measure the time taken to complete common consultation tasks compared with different electronic patient record system designs
5. To model the process flow and structure of the common consultation tasks to support evaluation of information system design features

Primary outcome measure

The measurements of time taken to complete common consultation tasks with different electronic patient record system designs

Secondary outcome measures

1. Process models and associated interpretations detailing the influence of system design characteristics on the consultation workflow.
2. A classification system representing the core aspects of consultation tasks analysis, also incorporating the contextual elements significant for study design, outcome interpretation and systems development.

1.4.2 Publications related to this study

1. de Lusignan S, Pearce C, Kumarapeli P,Stavropoulou C, Kushniruk AW, Sheikh A *and* Shachak A- **Taxonomy for evaluating the use of IT in the clinical consultation: A position statement from IMIA PCI WG (International Medical Informatics Association Primary Care Informatics Working Group)** in IMIA *year book*, IMIA, (*2011*)
2. de Lusigna S, Nitsch D, Belsey J, Kumarapeli P. E Vamos, A Majeed *and* C Millett - **Disparities in testing for renal function in UK primary care: cross-sectional study** in *Family Practice*, Oxford University Press, June, DOI 10.1093/fampra/cmr036 (*2011*)
3. Michalakidis G, Kumarapeli P, Ring A, van Vlymen J, Krause P *and* de Lusignan S- **A system for solution-orientated reporting of errors associated with the extraction of routinely collected clinical data for research and quality improvement** in Studies in Health Technology and Informatics, (160) IOS Press, pp. 724-8. DOI 10.3233/978-1-60750-588-4-724 (*2010*)
4. Debar S, Kumarapeli P, Kaski JC, de Lusignan S. **Addressing modifiable risk factors for coronary heart disease in primary care: an evidence-base lost in translation**. Fam Pract. 2010 Apr 22
5. Pflug B, Kumarapeli P, van Vlymen J, Ammenwerth E, de Lusignan S. **Measuring the impact of the computer on the consultation: an open source application to combine multiple observational outputs.** Inform Health Soc Care. 2010 Jan;35(1):10-24
6. de Lusignan S, Kumarapeli P, Debar S, Kushniruk AW, Pearce C. **Using an open source observational tool to measure the influence of the doctor's consulting style and the computer system on the outcomes of the clinical consultation.** Stud Health Technol Inform. 2009;150:1017-21.
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8. Kumarapeli P, Debar S, Chan T, de Lusignan S. **A rational basis for selecting a clinical computer system: video analysis of the impact of four different brands of computer system on the consultation** Proceedings of Society of Academic Primary Care Annual Scientific Meeting 2009. 2009 July 8-10.
9. de Lusignan S, Kumarapeli P, Chan T, Pflug B, van Vlymen J, Jones B, Freeman GK. **The ALFA (Activity Log Files Aggregation) toolkit: a method for precise observation of the consultation.** Journal of Medical Internet Research. 2008 Sep 8;10(4):e27
10. Bhanahbai H, Kumarapeli P, de Lusignan S. **The use of silence in the computer mediated consultation.** Proceedings of Society of Academic Primary Care Annual Scientific Meeting 2008. 2008 July 9-11.
11. de Lusignan S, Kumarapeli P,. **Measuring the impact of the computer on the consultation.** Proceedings of Society of Academic Primary Care Annual Scientific Meeting 2008. 2008 July 9-11.

12. Pflug B, Kumarapeli P, van Vlymen J, Chan T, Ammenwerth E, de Lusignan S. **Measuring the impact of the computer on the consultation: An application to synchronise multi-channel video, automated monitoring, and rating scales**. Proceedings of Healthcare Computing 2008. 2008 April 22-24.

13. Refsum C, Kumarapeli P, Gunaratne A, Dodds R, Hasan A, de Lusignan S. **Measuring the impact of different brands of computer systems on the clinical consultation: a pilot study.** Inform Prim Care. 2008;16(2):119-27.

14. Kumarapeli P, de Lusignan S, Koczan P, Jones B, Sheeler I. **The feasibility of using UML to compare the impact of different brands of computer system on the clinical consultation.** Informatics in Primary Care. 2007;15(4):245-53.

15. Kumarapeli P, Dodds R, de Lusignan S, **Observing and Modelling the Core Computer-based Activities of the General Practice Consultation,** Proceedings of European Federation for Medical Informatics – Special Topic conference (EFMI STC2007), 2007 Apr; pp 43-49.

16. Kumarapeli P, de Lusignan S, Ellis T, Jones B. **Using Unified Modelling Language (UML) as a process-modelling technique for clinical-research process improvement**. Medical Informatics and Internet in Medicine 2007:32(1):51-64

17. Moulene MV, de Lusignan S, Freeman G, van Vlymen J, Sheeler I, Singleton A, Kumarapeli P. **Assessing the impact of recording quality target data on the GP consultation using multi-channel video.** Medinfo. 2007;12(Pt 2):1132-6

18. Kumarapeli P, Stepaniuk R, de Lusignan S, Williams R, Rowlands G. **Ethnicity recording in general practice computer systems.** Oxford Journal of Public Health 2006;28(3):283-7.

19. Kumarapeli P, de Lusignan S, Ellis T, Jones B, **Using Unified Modelling Language (UML) to improve the processing of routinely collected clinical data,** Proceedings of Healthcare Computing 2006, 2006 March; pp. 273-283.

20. Kumarapeli P, de Lusignan S, Robinson J, **Online resources for chronic kidney disease (CKD) for primary care,** Informatics in primary care, 2006;14(2); pp 139-42

21. de Lusignan S. Hague N, van Vlymen J, Kumarapeli P. **Routinely collected data are complex, but with systematic processing can be used for quality improvement and research.** Inform Prim Care 2006:14(1);59-66.

1.5 A guide to the thesis

Chapter 1 introduces the research background and the impetus for this research. It defines the key concepts associated with the problem domain and discusses the lack of understanding about the functioning of the clinical information systems within the consultation. It further emphasises the need for gauging the influence of the computer in consultation in order to enhance performance of computer assisted consultations. Finally the research question, aim, objectives and outcome measures are presented.

Chapter 2 describes the initial literature review process and presents the findings under four themes; (1) the content, context and values of the clinical consultation, (2) impact of the computer on the primary care consultation, (3) consultation observation approaches and (4) the strategies for investigating the consultation to support information system solutions. It then presents the implications of the literature review and the design of the research process.

Chapter 3 presents a notional insight into the general practice consultation by reviewing the theoretical models of consultation. It discusses the progressive transformations of the consultation perspectives based on the changes in theoretical frameworks; their orientations and presentation of the consultation content and structures. This chapter also explores the various observation techniques used for clinical consultation research and discusses their outcomes, analysis methods and theoretical basis.

Chapter 4 details the research design and the technical method. It justifies the enhancement done to the technical profile of a multi-channel video recording approach. This section also introduces various software components developed to improve the data collection and processing tasks. Processing steps followed to produce multi-channel videos from observed consultations, and the data processing tasks are also introduced here.

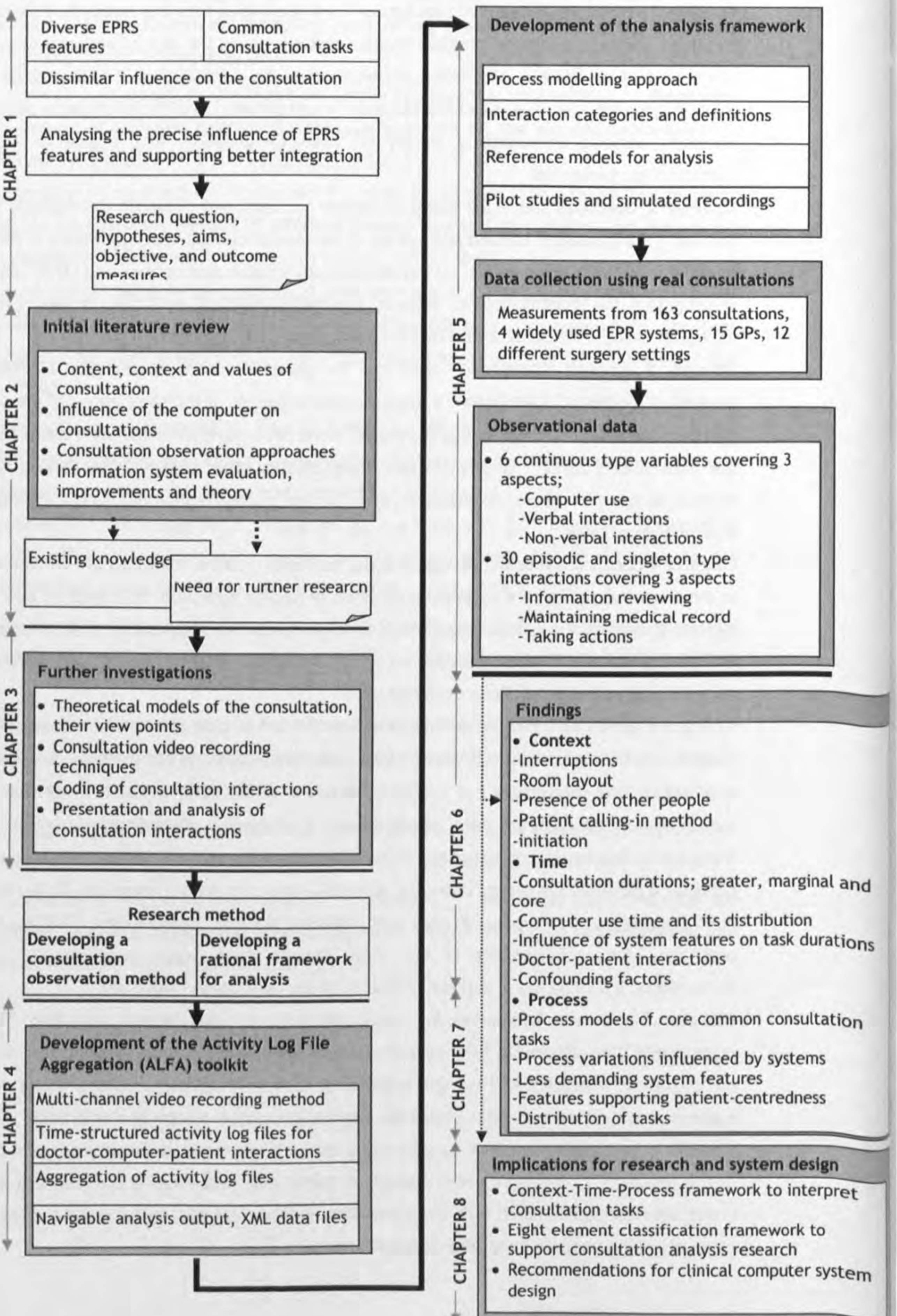
Chapter 5 describes the observational study carried out as part of this research involving real-life general practice consultations. It presents the rationale to use real consultations followed by ethics approval, patient recruitment and consenting aspects of the study. This chapter also introduces the approach adopted for data analysis and presentation of findings. A set of theoretical frameworks developed or adopted to interpret the observational findings are also discussed.

Chapter 6 presents the results of the experimental study conducted using real-life general practice consultations across number of sites with different doctors, patients and EPR systems. After presenting the characteristics of the study sample, this section presents the results that demonstrate the influence of contextual factors on the consultation workflow.

Chapter 7 presents further results associated with the consultation workflow. This section investigates the relationship EPR system designs are having with the consultation workflow and doctor-patient interactions. Findings associated with task durations and process models are presented with references made to specific information system design characteristics.

Chapter 8 concludes the thesis by presenting the principle findings, implications and conclusions of the research. It also presents a theoretical framework incorporating the common consultation tasks, their variations linked with the information system features, and the associated contextual elements of the computer assisted consultations.

1.6 Research design – a schematic diagram



1.7 Summary

This chapter described the background associated with this study, followed by the specific research question and hypotheses that were considered. Computer is an integral element for primary care delivery. Computer use has enhanced the effectiveness of consultation tasks. There are a number of organically developed clinical computer systems used in the UK general practice. They have diverse system design features, potentially having a varied influence on the consultation workflow. Computer use may introduce unexpected changes to the consultation workflow. Despite increased use of computers, both patient and clinicians still have reservations about their role in the consultation. There is a dearth of evidence about the precise influence different system design features may have when performing common consultation tasks. Clinicians may get cognitively overloaded as a result of the information demands coming from the computer. This could influence the clinician-patient interactions. There is a need for an evidence base to facilitate clinical system design improvements, user education and training to achieve improved clinical system integration to the consultation workflow. This chapter also presented an introduction to the adopted research design and also indicated the structure followed in this thesis to present the decisions, outcomes and findings of this study.

CHAPTER 2

Review of the literature

2.1 Chapter introduction

This chapter provides an introduction to the existing body of literature associated with the primary and sub hypotheses addressed by this thesis. It first establishes the intentions, scope, process, findings and implications of the literature review. Then a description of the adopted reviewing method has been explained. This clarification of the review process primarily aims to corroborate its relevance to the research objective and to assure its repeatability. The tasks described in this section have been carried out with the purpose of further substantiating the rationale for this research and to inform the state of the art related to eight sub-hypothesis linked to this project.

The interdisciplinary nature of this research and the endeavours to establish the historical perspectives related to a number of allied topics should have resulted in discovering a vast amount of literature. In fact, there proved to be a dearth of publications linked to the precise research question. It should be noted that the presentation of the findings in this section, utilises the publications relevant to both clinical consultation and information systems domains. Later parts of this chapter focuses on critically appraising the themes discovered and presents the implications of the literature review findings

2.2 Literature review process

2.2.1 Approach and aims

This review initially established a set of aims. They were ascertained by deconstructing the research question. Each aim has five further ancillary sub-categories, dealing with a more specific area of research.

This formulation of objectives and the assessment criteria have been chiefly driven by the research objectives and selected to be attuned with the progressive nature of primary care informatics domain. The approach of this review has been influenced by the models proposed by Cooper (1988), Bell J (1999), Garrard J(2006) and Lawrence et al. (2008).
To facilitate the selection and to guide the evaluation of the literature, the review aims have been transformed into a set of quality criteria (table 2.1)

Describes the content and context of the primary care consultation	
A.	Defines the consultation process and its boundaries
B.	Identifies the objectives of the consultation
C.	Presents the functional components of consultation
D.	Discusses the variations of consultation and influential factors
E.	Describes the factors determining a successful consultation
Describes the impact of information systems on the consultation	
A.	Describes the functioning of information systems in clinical context
B.	Describes the use of information systems in primary care consultation setting
C.	Identifies the influence of information systems on consultation tasks and outcomes
D.	Describes the progressive changes in the clinical information systems
E.	Describes the challenges in integrating information systems to clinical consultation
Describes potential for measuring the impact of information system characteristics on the consultation	
A.	Defines and describes the doctor-computer interactions and consultation tasks
B.	Describes strategies for identifying the consultation tasks, their variations
C.	Describes the association between the information system design characteristics with their use in clinical consultations
D.	Discusses the criteria for recognising successful information solutions
E.	Evaluates approaches available for improving information systems
Describes techniques for investigating the consultation interactions to support selection and development of information system solutions	
A.	Describes the techniques available to evaluate computer-assisted consultation
B.	Describes approaches for linking consultation process with information system use
C.	Describes the importance of recognising the mutual influence between the computer use and social interactions
D.	Discusses the suitable approaches for improving the computer-assisted consultation's tasks and process structures
E.	Evaluates process abstraction and presentation approaches to enhance the doctor-computer-patient interactions
Presents theoretical frameworks to contextualise the consultation content and impact of information systems	
A.	Presents theoretical frameworks associated with information systems
B.	Presents theoretical frameworks on the acceptance of the information system solutions
C.	Describes the theoretical views on the consultation and progressive changes
D.	Presents theoretical approaches for gaining insight into users and their interactions with the technology
E.	Presents theoretical models on computer-assisted clinical consultations

Table 2.1 Quality criteria for literature search and selection

2.2.2 Review process, characteristics and descriptors

Cooper (2009) proposes a taxonomy with six elements defining the characteristics of a literature review; focus, goal, perspective, coverage, organisation and audience.

The 'focus' of this review is to develop a research rationale to fulfil an existing information gap and to identify outcome measures and analysis methods to inform the research. The 'goal' is to identify central issues, critical analysis and integration of principle findings. The 'perspective' is neutral with a 'coverage' of selective citations. The 'organisation' of the review results is conceptual, based on relationship with the research rationale. The 'audience' is specialised and general scholars. The following descriptors define the search strategy;

→ **Discipline:** Health informatics (HI), primary care informatics, Information system analysis, Software engineering, Business process modelling (BPM).

→ **Type of publications:** Journals (electronic and printed), books (electronic and printed), conference proceedings, bibliographies, web sites

→ **Type of literatures:** Quantitative research, qualitative research, theories, methodologies, guidelines, policy documents, workshop outcomes.

The author carried out the literature review primarily to identify the existing observation methods, and models of for conducting effective consultations in primary care. Publications related to the techniques capable of observing the use and influence of IT during primary care consultations were also considered. Theoretical models on consultation were reviewed to recognise the characteristics of successful clinical encounters and the role of doctor-patient communication. The author's investigation also considered the knowledgebase on the consultation tasks; functionalities offered by clinical systems and associated compounding factors.

Bibliographic databases and specialised search engines have been mostly used to identify the relevant literature. They are; (1) Medline (*www.pubmed.gov*), (2) Embase (*www.embase.com*) (3) Zetoc (*www.zetoc.mimas.ac.uk*) (4) eBizSearch (*smealsearch2.psu.edu*), (5) CiteSeer (*www.citeseer.ist.psu.edu*) and (6) Directory of open access journals (*www.doaj.org*). Findings from these tools have been supplemented and extended by the use of supplementary methods. They are; (1) PubMed's related article feature, (2)) citation indexing services. and (3) reference lists of the selected literature. Four citation indexing services have been used; (1) Scopus (*www.scopus.com*), (2) Google scholar (*scholar.google.com*), (3) CiteSeer (*citeseer.ist.psu.edu*) and (4) ISI web of science (*portal.isiknowledge.com*).

2.2.3 Keywords and MeSH (Medical Subject Heading) terms

The literature search stage utilised a set of keywords to distinguish the published literature pertinent to the research question. These keywords belong to two categories reflecting the disciplines that overlap in the problem domain of this research, namely information systems and primary care consultations. MeSH is a controlled vocabulary designed by the National Library of Medicine to search in sciences databases.

Information Systems keywords	Process modelling; Business process modelling; Information systems; Process mapping; Process improvement; Computerisation; Computer systems simulation; System evaluation; Information management; Information theory
Primary care keywords	Primary care; Family practice; Primary care consultation; Consultation models; Clinical encounters; Clinical reasoning; Clinical guidelines; Data quality; Medical record systems, Evidence-based medicine; Theoretical models; Video recordings; General practice; Data collection
MeSH terms	Information storage and retrieval; Medical records systems, computerized; Medical informatics; Decision modelling; Process assessment; Model, theoretical; Primary care; Healthcare research; Data collection

Table 2.1: Search terms used for the literature identification

Most of the bibliographic databases provide facilities to query their content by combining several key words using Boolean operators. The 'AND' operator has been used to combine two or more key words from each of the search categories explained above. Examples for such combinations are; Primary care AND Process modelling, Primary Care Consultation AND Computerisation, Clinical encounters AND Computerisation AND Data quality

2.3 General practice consultation

2.3.1 Theoretical representations of the consultation

Researchers have explored diverse aspects of the encounter that takes place between the clinician and the patient during the consultation. Some have resulted in proposing theoretical models describing or prescribing the content and structure. Most of the proposed models have been based on consensus and opinion, rather than on rigorous scientific methods (Kurtz et al., 2003; de Lusignan et al., 2003).

In the late 1950s, Balint emphasised the need for the doctor to appreciate the therapeutic effect the consultation has on the patient (Balint, 1957). He observed that treating only the medical problem had limited advantages and emphasised the wider benefits of treating patients using a holistic approach. In early 1960s Gelat (1962) discussed the skills required to perform the consultation tasks. The RCGP (1972) proposed the 'Triaxial model' which acknowledges the existence of the clinical, psychological and social dimensions of a disease, and their possible variations. The transaction analysis models proposed by Berne (1973) interpreted the consultation as an encounter between the parent-like doctor and a child-like patient, and recommended utilising a psychological understanding when manoeuvring the consultation process.

Byrne and Long (1976), after analysing observations of audio recorded consultation, proposed a common structure to explain the consultation process. This model with six phases explained various behavioural aspects linked to consultation tasks, particularly the 'illness' aspect of the presenting problem and the importance of patients' contributions to decision making. Engel (1977) defined this 'all encompassing' approach more precisely by application of the term 'biopsychosocial' to the consultation theories. This term acknowledge the need for considering the psychological and social dimensions of the disease together with its pathological form. Pendleton (1984) reported the need for acknowledging the ideas and beliefs of the patients, advising that failing to do so would result in patients either not complying with the given advice or not understanding its relevance. This model also presented a set of key consultation tasks. Neighbour further elaborated this by introducing the general practice consultation as a 'journey' rather than a 'destination'.

Theoretical models introduced in late 1990s and later, gradually promoted the patient's role in decision making, the importance of shared understanding and the narrative aspects of the consultation. Then the notion of patient centeredness became acknowledged as a fundamental principal, on which basis the consultation should be delivered (Little et al.., 2001). Patient-centred medicine focuses on assessment of the patient as a whole as opposed to concentrating on disease management. This approach incorporates strategies for showing empathy towards patients' concerns and assessing their expectations. The Calgary-Cambridge model, which has been used widely for GP training emphasises the adoption of patient- centred approaches when performing consultation tasks (Kurtz S and Silverman, 1996). However, none of the popular theoretical models considers using the computer, despite its increased use to assist the consultation process. As a result of this some researchers extended the coverage of existing widely used consultation models to include tasks representing computer use (de Lusignan, 2002).

2.3.2 Decision making

Successful utilisation of available consultation time in working towards a positive outcome often depends on previous decisions. Pendleton et al. recognised the conditional nature of decision making within the clinical practice; how a clinician's judgement is framed by the individual perspective of the problem in hand with the patient present (Pendleton et al.,1984). The diagnostic hypothesis exploration and collection of applicable information are key components in the diagnostic process.

Stewart et al. (1997) reported the positive influence of clear information. They also emphasised the importance of the awareness between doctor and patient about the problem under consideration and the plan for its management. Street et al. (1997) reported similar views and how the decision making could be affected by the patients' personality.

Regardless of the resources available, patient participation is also important for decision making. The communication skills expected from the clinicians, that were traditionally attributed to the consultation tasks, such as establishing rapport and discovering the reasons for attendance, are now being changed by the new move towards working in partnership. Sustaining the shared decision making agenda is exigent considering the numerous constrictions surrounding the primary care consultations (Elwyn, 1999).

Clinicians are now required to be skilful not only in exploring patients' preferences, sensitiveness, empowering them to engage in the disease management, motivating them to apply 'self help', sharing responsibilities, but also identifying those patients who prefer to remain as a passive participant (Thorsen,2001).

Based on the literature findings there are certain concepts that are prominently linked to the decision making process. Three such notions are referenced below. Acknowledging them is essential considering the influence they have on the consultation interactions, particularly the use of the computer to achieve the immediate and long-term objectives of the consultation.

2.3.3 Availability of information

The utilisation of information and the application of knowledge is a principal phenomenon that happens within the consultation. This has to be recognised by software engineers, in order to develop information systems capable of meeting the requirements of a clinical consultation. The information supply from the computer system to the GP may take the form of a series of messages describing the historical data relative to the patient; for example, past blood pressure readings may assist the GP to judge the effectiveness of a recommended therapy. An underlying pre-requisite for effective patient engagement is the ability of both parties to access constructive information (Shepperd,1999), hence the overriding role of the information architecture.

Information is contextualised data, or data that have been given more value through relational connections. Information helps the user to understand the data or provides insight into them. There are large amounts of information a GP can access through online sources, provided by the clinical system's built-in knowledgebase, from professional bodies or through the public internet. However, GP users could be overwhelmed by assessing the relevance of all the information during a consultation relevant to the ongoing problem and the patient (Gray,1998). Now there are information sources explicitly designed to support the specific information needs of the GPs (de Lusignan,2002). As stated by James (2001), readily available information is crucial for the application of care pathways, ideally with fewer disturbances to the consultation workflow.

"They must present the right information, in the right format, at the right time, without requiring special effort. In other words, they cannot reduce clinical productivity" (James, 2001:991-2)

Box 2.1: Importance of information availability

There are also findings suggesting that sometimes patients' desire to obtain information related to their condition is greater than their eagerness to participate in decision making (Beisecker, 1990). However, the evidence base is insufficient, due to the limited number of studies focused on the decision making phase of the consultation. The format of the information presented in the consultation also influences this process. Clinicians may decide to share information through verbal means or through a graphical representation (Elwyn, 2000).

- Involves two or more participants
- Both parties should actively take part
- Should be facilitated by shared Information – a prerequisite
- An agreed decision should be made

Box 2.2: Characteristics of shared decision making process in consultations

Patients might become dissatisfied if they do not receive sufficient information about their condition and the treatments (Coulter,2001; 2003). The notion of acknowledging the patients' ideas, concerns and expectations has a novel dimension as a result of patients arriving for their appointments equipped with internet-derived information. A health foundation survey in 2005 found 30% of the patients aged 45 and over accessing the internet searching for health information (Ellins, 2005). Increased access to useful information has enabled the doctor-patient relationship to become an active collaboration.

2.3.4 Managing the knowledge

There is an inherent risk of having too much accessible information having an impact on the focus of a consultation. A clinician's ability to develop his or her own knowledge management strategy is important for the effective management of the consultation process (de Lusignan et al.,2002). Knowledge informs the user about what to do with the information (Bellinger et al.,2004). It is conditional, it represents the patterns that can be ascertained associated with a given collection of information. Knowledge management involves a human or soft aspect as well as a technical dimension (Hlupic et al., 2002).

Polyani classified the knowledge in two forms; explicit and tacit (Polanyi, 1966). Explicit knowledge can be articulated, codified and stored. The evidence-based practice is an example of the utilisation of this form of knowledge. Tacit knowledge in contrast cannot be codified or exchanged in written form and is mostly in the practitioner and associated culture. Tacit knowledge can be classified further based on its 'cognitive' and 'mental' dimensions (Welsh and Lyons,2001). The cognitive aspect represents the know-how or the clinician's own personal skills acquired or developed through experience. The mental dimension represents the beliefs, values, ideas and schemata associated with professional practice. There are two strategies widely adopted by users and recognised by information system designers for knowledge management; the codification and the personalisation of knowledge (McMahon,2001). Personalisation approaches develop systems, solutions to meet the requirements of individual users while the codification strategies attempt to design solutions around frequently used routines.

2.3.5 Practicing evidence-based medicine (EBM)

Patients present unstructured problems to their general practitioners. GPs then adopt a heuristic approach for decision making to manage the problem and the patients' concerns (Sullivan, 2001). Evidence Based Medicine (EBM) has become a core element in practicing medicine over the last 15 years (Timmermans, 2005). Guyatt et al.. (1992) used the term for the first time in a paper published in *JAMA* in 1992. Box 2.4 presents a definition of EBM.

Within the consultation workflow, clinicians are faced with challenges pertaining to the awareness, identification and application of EBM (Guyatt, 2004) . This has introduced a new dimension for patient involvement; sharing the EBM elements, incorporating it to disease management and pervading the consultation. Application of EBM can be categorised in two levels (Eddy,2005);

(1) The institutional level integration – evidence-based guidelines/health care

(2) The evidence-based decision making by an individual clinician.

Both levels play an important role within the consultation process. Sackett et al.. (2000) introduce EBM as the sensible use of the current best evidence for decision making . They mention a framework consisting of five steps (Box 2.5) for integrating EBM to clinical practice.

"The conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence-based medicine requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research and patient's unique values and circumstances."

Box 2.3; Evidence-Based Medicine (Evidence-Based Medicine Working Group, 1992)

1. Translating the need for information to an answerable question
2. Systematic retrieval of available best evidence
3. Appraisal of available evidence for validity, relevance and applicability
4. Application of findings to practice – integrate with clinician's expertise, and with patient's biology, values and circumstances
5. Evaluation of performance

Box 2.4: Application of EBM to the consultation

There are concerns about the restrictive structure this notion could bring into the consultation. Greenhalgh (1999) commented on the risk associated with relying on EBM unnecessarily; particularly the negative impact it could have on a consultation's narrative dimension. Maintaining a balance between the clinical governance responsibilities and practicing EBM has been a challenge faced by practitioners (Halligan, 2001). There is a demand for exploring strategies that maintain a balance between patient-centred care and evidence-based practice (Theodom et al.., 2003), both of which are important when analysing the consultations.

2.3.6 Impact of QOF on data recording

The introduction of the Quality and Outcomes Framework (QOF) has influenced the primary care consultation's content and the characteristics of the doctor-computer interactions. The (QOF), is a performance mechanism which has electronic patient records with coded data, disease registers, laboratory results and prescribing data as its main components (Guthrie et al.., 2006). Most QOF disease areas showed increased level of data recording in the medical records (Campbell, 2008; Stroke, 2006) . One study showed more then 50% increment of data recording levels for patients with diabetes just after the first year since the introduction of the programme, and also significant increments in the associated quality indicators. Some studies showed improvements in the quality of care measurements and health outcomes related to range of clinical conditions (Campbell et al., 2007).

Prescribing patterns have also changed (MacBride-Stewart, 2008). Increment of prescriptions recorded using generic drug names has been observed. Similar changes have occurred in the secondary care referral patterns; for example, an increment in number of new patients referred with renal diseases was noticed after the introduction of the CKD clinical domain (Phillips et al., 2009; Hobbs et al., 2009).

There is now increased demand for engaging in consultation tasks linked to chronic disease management and health promotion (Mechanic, 2001).

Opinions have been expressed about the over-emphasis on coded data recorded into a medical record during the consultation, because of the possibility of it altering the consultation process and weakening the patient-centred agenda in order to meet information demands set by the financial incentives (Lipman,2004) . Evidence for using 'gaming' strategies to increase the prospects of meeting targets also exist. For example, one study showed the exaggerated fall of blood pressure measurements due to values getting clustered just below the QOF target levels (Carey et al., 2006). Another study concluded the awareness amongst both the GP and the patient about the leeway of manipulating clinical indicators to achieve the desired results (Dowrick, 2009) . There were also concerns about the differences between diagnosis codes found in disease registers maintained for QOF related analysis and the actual number of patients meeting the diagnosis criteria (McGovern et al., 2008). A similar observation was made concerning the appropriateness of referrals compared to those recorded against QOF indicators (Phillips, 2009) . Lester et al. argued about the risk of reintroducing the elements of disease orientations and development of a 'ticking box' attitude for the consultation (Lester, 2006)

2.3.7 Doctor-patient relationship and interactions

The primary care consultation brings about a subtle social interaction between its human participants. The relationship between the clinician and the patient is a unique and an elemental feature of the general practice (Stewart et al., 2003; Saultz, 2003) . Montague (1963) described the consultation as an exceptional one-to-one encounter. Freeman et al. (2002) also presented the influential association of the doctor-patient relationship with responding to patients' concerns and productive consultation tasks.

Coulter interpreted the partnership style of relationship within the consultation as an alternative for the traditional paternalistic approach (Coulter, 1999). She presented the benefits of having a mutual respect between the doctor and the patient about their skills, competences and knowledge. According to Coulter, the partnership approach recognises collaborations in four facets; (1) shared information, (2) shared evaluation, (3) shared decision making and (4) shared responsibilities. Those four dimensions cover all the main consultation tasks. Kurts et al. (2003) argued the need for interactions aimed at establishing rapport at the consultation initiation, considering its influence on discovery of the presenting problem.

The doctor's ability to communicate effectively with the patient is a fundamental feature of the consultation. Balint (1957) called for recognition of the therapeutic influence the doctor's interactions have on the patient. The influential work of Szasz (1956) also demonstrated the association between the quality interactions and positive patient outcomes. The Toronto consensus statement also concluded the effective communication as the central element for practicing good medicine (Simpson et al., 1991) . The GP training now acknowledges the significance of acquiring the communication skills needed to conduct an effective patient-centred consultation.

There are many reported benefits of having good doctor-patient interactions. The style of interactions influences patient satisfaction and behaviours. The 2005 national primary care patient survey reported how the positive experiences patients have had pertaining to their interactions with the doctors have contributed to maintenance of better relationships (Healthcare Commission, 2005).

Good doctor-patient interactions need commitments from both parties. Regardless of the doctor's effort, the success of the consultation may depend on the patient characteristics as well (Willems et al., 2005). The patient's characteristics are particularly significant with regards to the verbal interactions. Despite the evidence linking good communication to positive outcomes, its precise impact on modifying health care remains unclear.

2.3.8 Influence of non-verbal interactions

Often, verbal interactions have been used as a surrogate to study interactions between the doctor and the patient. However, non-verbal behaviour is increasingly recognised as a significant factor in a consultation (Willems et al., 2005). In clinical consultations, eye contact is considered to be very influential in non-verbal communication. It assists in establishing rapport, indicates that the doctor is engaged and confirms the doctor's willingness to understand the patient's concerns (Maguire, 2002). Similarly, affirmative head nodding and leaning towards the patient have been recognised as having an influential role (Campbell et al., 2001). In addition, Heintzman et al. (1993) reported affectionate touching and smiling as having an encouraging influence on patient's perceptions and satisfaction with the consultation.

2.3.9 Impact of interruptions

When representing the consultation, it is important to represent the internal and external factors that could modify consultations such as interruptions. Reported observations related to interruptions are mostly associated with doctor-patient communication, as a conversational phenomenon.

Interruptions could have a severe impact on the opening sequence of a consultation. On such occasions the doctor could possibly miss opportunities for capturing potentially vital patient information and also lead to late-arising concerns (Marvel et al., 1999). A review conducted on the Rotar Interaction Analysis System (RIAS), has previously suggested the inclusion of interruption as an observational element for doctor-patient communication; however the suggestion is to interpret it on a case by case basis (Roter, 1993).

Sullivan (1995) discussed the impact of interruptions on the confidentiality and the doctor-patient relationship within a consultation. He listed telephone calls, teaching activities, video recording, guidelines, protocols, health promotions and the computer as interruption sources. He suggested altering the computer use and the placement of the computer screen to minimise interruptions caused by the computer. Dearden et al. (1996) reported that 10.2% of 102 consultations they observed were interrupted, and cited the telephone as the commonest source (50%). Of the patients whose consultations were interrupted, 20% thought of it as having a negative impact and 40% preferred not getting interrupted during the consultation.

2.3.10 Patient-centred consultation style

With regards to the role played by the doctor in driving his or her interactions with the patient, the existence of two different traditions is apparent. The doctor dominated, directive style assumes a paternalistic role of the doctor who advises the patient based on own judgments, whereas the partnership or sharing style recommends the doctor and the patient to share the decision making and the responsibilities (Taylor, 2009; Street et al., 2007)).

The levels of understanding patients have about the consultation and the space they get to negotiate regarding their care have a significant impact on their experience and the health outcome (Lewin et al., 2007) . Association between the patient satisfaction and better health outcomes is also well recognised. Satisfied patients tend to adhere to their prescribed treatments better, have a higher level of understanding about their condition, show more commitment to recommended lifestyle changes and in general attempt to maintain a better quality of life (Kinnersly et al., 2000).

The patient-centred style of consulting, where the clinician actively considers the patient's ideas, concerns and expectations associated with the presenting problem is acknowledged as the most favourable (Pendleton et al., 1984; Moran et al., 2008) ". It recognises the patient's opinion about the disease, the experience of illness and expectations about medical care, moving beyond the focusing only on symptoms. Stewart (1984) and Kinnersly et al. (2000) present how the patient-centred practice could have a positive impact on patient satisfaction represented similar results.

A review by Mead et al. (2002) aimed at identifying the relationship between the patient-centred consultation styles and the treatment outcome also acknowledges a closer relationship. The same study proposed five separate dimensions of a patient-centred consulting style;

(1) The biopsychosocial perspective – biomedical, social and psychological dimensions of illness

(2) Sharing power and responsibility

(3) Therapeutic alliance – developing common therapeutic goals and agreements

(4) The 'patient as person' approach – understanding the personal meaning of illness

(5) The 'doctor as person' approach – awareness about the doctor's influence.

Their study further established wider contextual issues associated with patient-centred practice. Those factors are categorized into six groups as patient factors, doctor factors, professional context, consultation level factors, time and 'shapers' (Image 2.1).

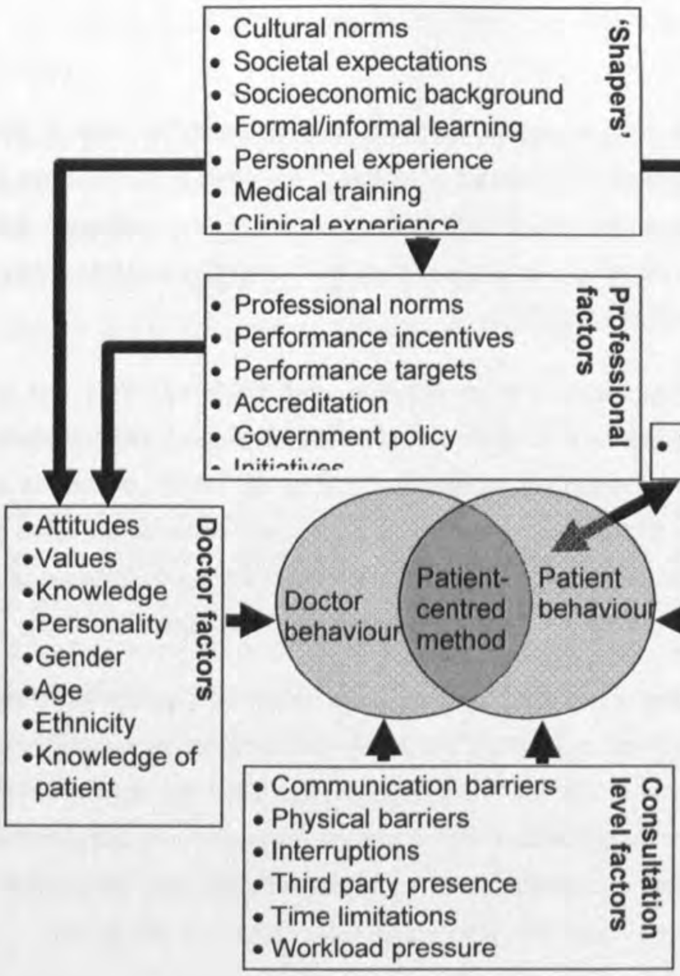


Figure 2.1: Factors influencing the patient-centred practice (based on Mead and Bower, 2000, p1104)

Little et al., (2001) investigated patient perception of the patient-centred consultation, and their association with the consultation outcomes. This study reported five measurable elements of patient perception; (1) personal relationship, (2) communication and partnership, (3) positive approach to diagnosis and prognosis, (4) health promotion and (5) interest in the effect on life.

Despite wider acknowledgement of the positive outcomes linked to the patient-centred consultation approach, there are concerns about its practical application (Barry et al., 2000). The style of consulting can also vary between doctors, and from one consultation to another. A fixed style of consultation is in fact regarded as an obstacle for establishing doctor-patient rapport (RCGP, 1984).

2.3.11 Biopsychosocial approach

In the early 18[th] century Foucault (1973) introduced the association between clinical observations and resultant pathological findings. Later on, this led to the establishment of the elements of symptoms, signs and examinations. Those rudiments essentially acknowledged the existence of two standpoints; the patient's experience about the illness and the doctor's ability to infer after examinations.

Engel (1977) proposed a 'biopsychosocial' model that considers the social, psychological and behavioural dimensions of the patient's illness. The model assumes that there are objectively observable facts and method for dealing with the disease but not for interpreting the patient's real concerns.

The practical application of the biopsychosocial approach mainly depends on the consultation style adopted by the clinician (Engel, 1982 & 1990)'. A doctor giving sufficient attention to the patient's agenda, involving the patient in decision making and sharing the control are the trends that should become apparent in a consultation that has considered the biopsychosocial dimension (Lewin et al., 2001) . There have been attempts to develop instruments that measure behaviours within consultations. For example, the evaluation tool proposed by Margalit et al. (2007) asks the reviewers to rate their observations under six categories;

1. Addressing the psychosocial background of the patient
2. Reassuring during physical examination
3. Checking whether patient agrees with the diagnosis
4. Integrating biomedical and psychosocial treatment plan
5. Verifying patient's agreement with the suggested treatment
6. Offering help beyond patient expectation

It should be noted that some of the above elements are also associated with patient-centred care. There have been observations suggesting that the application of the biopsychosocial approach need not lengthen the consultation time and may in fact improve patient satisfaction and provide economic gains to the health service (Margalit et al., 2004).

2.3.12 Recognising a 'Good consultation'

The idea of assessing the success of a general practice consultation has been regarded as challenging if not unrealistic (Howie et al.., 2005; Evans et al., 2007) . This is primarily owing to the complex nature of the problems addressed in primary care. Regardless of those challenges, a number of measurement instruments have been in use. The CQI (Consultation Quality Index) tool kit (Howie et al.,, 2004) has the consultation length and the doctor patient rapport as two process measures, and the 'patient enablement' as an outcome measure. Assessment tools like MISS (Medical interview Satisfaction Scale) and CSQ (Consultation Satisfaction Questionnaire) measure patient satisfaction. PEI (Patient Enablement Instrument) also measures patient satisfaction, however, with more emphasis on the patient's original expectations (Howie et al.,2005). The CARE (Consultational and Relational Empathy) tool uses the empathy expressed by the clinician as a process measure (Mercer et al., 2004).

A literature review by Hanne et al. (2001) identifies two categories of measures useful for assessing the quality of general practice consultation; outcome measure and process measures. The frequently used process measures are the performance indicators, audit criteria and rates of prescribing, referral, examinations, screening and follow-ups. Outcome measures mostly include questionnaire-based approaches to assess patient satisfaction and its various related parameters, and clinical outcomes such as achievements linked to chronic disease management. In conclusion, Hanne and colleagues justify the importance of recognising the patients' 'priori wishes' instead of comparing the consultation outcome against the patient's expectations about 'likely outcomes'.

Anderson et al. (1994) for their post-consultation patient satisfaction questionnaire define a 'good consultation' based on three elements;

1. Patient and doctor agreeing on the consultation objectives – mutual understanding about the problem
2. Patients having a sufficient amount of freedom to explain their views about the problem
3. Patients' satisfaction on the length of consultation time.

Outcomes in this study link consultation success to the doctor's working style, and no significant association with the consultation length, patients' age, gender or continuity of care aspects.

Howie et al., (2004) after analysing the notions and their evolution pertaining to the core values of the consultation, proposed a consultation assessment instrument based on the concepts of 'patient centeredness' and 'holism'. Holism in this instance refers to the consideration of biopsychosocial elements when assessing the patient's presenting problem. Both these concepts have been promoted by a number of theoretical models for consultations. They are also accepted as core components in the more recent European definition on Primary care (Allen et al., 2002).

2.4 Impact of the information systems use on the consultation

2.4.1 Triadic interactions

The general practice consultation has been mostly considered as a dyadic interaction between the doctor and the patient (Rosenberg et al., 2007). The theoretical models for consultations predominantly reflect a similar view. This notion has been challenged by the introduction of the computer to support the consultation tasks and by the ever increasing reliance by the clinician on information stored in the electronic medical record. The existence of the triadic form of interactions is now recognised. Scott (1996) defines this as a meaningful exchange between the doctor, computer and the patient. These three contributors have their own agendas and the potential to direct the consultation process accordingly (Pearce, 2009).

Pearce et al., (2008) detail the influence of the negotiations that take place across the agendas of the doctor, patient and the computer based on video recorded consultations. The research they have done focusing on the first minute of computer mediated consultations acknowledged this triadic partnership, where either of them could influence the initiation of the consultation. They report that the majority of the consultations were initiated by the doctors, and in some occasions where the computer initiated them, the consultation objectives were altered. Their study also report about a computer initiated consultation in which the opening statement of the patient was totally ignored.

Pearce et al. (2009) in a separate investigation based on video recorded consultations report the existence of a dyadic relationship in the best part of the consultation with only transient triadic relationship episodes; the patient mainly spends the time looking at the clinician and only for small durations both of them were looking at the computer screen.

2.4.2 Styles of doctor's computer use

A number of studies aimed at analysing the various phenomena in the computer- assisted consultations have recognised trends pertaining to the doctor-computer interactions. Fitter and Cruickshank (1983) introduce three different types of doctors, based on their style of computer use for the duration of the consultation;

1. 'Minimal' users interact with the computer only after the patient has left the consultation room.
2. 'Conversational' users interact with the consultation throughout the consultation alternating their attention between the computer and the patient.
3. 'Block' users interrupt the interactions with the patient to consult the computer, often leaving the patient inactive.

According to their observations, minimal users spend more time engaging directly with the patient than the other two types. However, the completeness of the patient record depends on the amount of details the doctor manages to recall successfully during the data recording.

A separate video-based study recognised that minimal users spend more time making eye contact with their patients and leaning towards them compared to block or conversational users (Theodom et al., 2003). Warshawsky et al. (1994) suggest the possibility of training the conversational users to become block users to improve the efficiency of computer use without lengthening the consultation durations.

Pearce et al. (2006) recognise three patterns of doctor behaviour in computer mediated consultations based on the level of interest doctors have in computer use;

1. Informational users spend most of the time interacting with the computer and their data gathering is often prompted by the computer screen
2. Interpersonal users spend more time interacting with the patient
3. Managerial users have a fusion of both the above patterns, alternating their attention between the computer and the patient.

There were also conclusions recognising the influence of the patients' perception about the computer on the doctors' style of using it (Pearce et al., 2008). Patients who ignored the role of the computer compelled the doctors to separate their interactions with the computer from those with the patient; converting them into two separate lines of dyadic interactions. In consultations where patients were more receptive about the role of the computer, doctors freely adopted a triadic partnership.

Booth et al. (2004) report three styles of computer use based on how doctors integrate it into the consultation;

1. 'Controlling' style users direct the patients not to disturb during computer use, establishing an episode of dyadic interactions
2. 'Responsive' or 'opportunistic' users look at the computer screen only during gaps in the conversation
3. 'Ignoring' type users continue with computer use disregarding any interactions by the patient.

The functional feature of the EPR system being used might also mould the interaction pattern. Some might prefer a "systematic" style – also described as 'form led'; working through the data entry forms or templates provided by the EPR systems, while others adopt a "personalised" style recording data as it emerged naturally in the consultation (Patel et al., 2002). The usual consulting style of the doctor also has a strong influence on computer use.

2.4.3 Amount of time spent using the computer

Computer use for longer periods could be the result either of increased data capturing or more time being spent seeking information. After a video-based study Pringle and Stewart-Evans (1990) reported the contribution of the computer in lengthening the duration of a consultation. According to Herzmark (1984), the computer screen presenting the EPR content requires more attention compared to the traditional paper-based version. Warshawsky (1993) observed that the length of time GPs spent interacting with the patient is less when using the computer-based medical record compared to the paper version. A video-based study reported that doctors on average spent 16% of the consultation time using the computer (Bui et al., 2005). A simulated video-based study reported doctors spending around a quarter of consulting time using the computer (Miguele et al., 2007).

2.4.4 Influence on the doctor-patient interaction

With the universal computerisation of primary care there have been concerns about the influence of computer use on doctor-patient interactions during a consultation and on the relationship between them in general. There have been concerns amongst doctors about the effect this could have on their ability to communicate effectively and their relationship with the patients (Western et al., 2001). The doctor may get a cognitive overload as a result of dealing with both information requests and offers coming from the computer and the patient demands in parallel. The end result could be an episode of suboptimal computer use or distraction from interactions with the patient.

Studies have also shown the association of the computer with the decline in patient-centred interactions and increased amount of doctor-centred verbal interactions (Pringle et al., 1985 & 1986)'. The number of medical topics brought into the consultation was also increased when computer use is involved. Furthermore, there is the possibility of the doctor missing important information and cues from the patient during computer use (Booth et al., 2004).

A video-based study carried out by Theodom et al. reports that the doctor turning away from the patient towards the computer is an attempt to exclude the patient from the interactions (Theodom et al., 2003). The same study argues that in situations where the doctor delayed computer use until the patient has left the room, the amount of clinical data entered was less. It further reports on some incidents where the doctor referred to the content of the computer screen to change the topic of discussion or to conclude the consultation.

Based on another observational study, Als (1997) interprets the computer as a "magic box", a tool enabling the doctor to obtain some "time out" from interactions with the patient, to add a higher value to the medical statements or to change the direction of the conversation. Greatbatch et al. (1995) report doctors exploiting the computer use as a means for creating silence or for delaying response to patient cues. Rhoades et al. (2001) also found the computer causing interruptions to the doctor-patient interactions. Unlike the doctor initiated interaction, these were not limited to the initiation phase of the consultations. In a separate study they found the influence of the computer changing the patterns of eye contact quite significantly (Rhoades et al.,2008).

A study looking at the first minute of a consultation reports how the computer can influence the initiation phase and even the direction of the consultation (Pearce et al.,2008). Pearce et al. discuss the potential of computer use within the consultation introducing an algorithmic rigidity (2006). They examined the influence of patient-centred approaches in rectifying the 'linear algorithmic' style brought into the consultation by the biomedical approach and how the computer might be reversing this improvement.

Theodom et al. (2003) report the influence of the prompts displayed by the computer system in defining the structure of the consultation. Furthermore, there are studies that analysed the impact of the QOF related EPR prompts on the consultation process using either quantitative or qualitative methods (McDonald et al. 2009)·

2.4.5 Patient perception about doctor's computer use

Patients generally favourably consider doctors using the computers in the consultations (Lelievre et al., 2010; . Ventres et al. (2006) recognise the importance of the patients' perception of the electronic health record's use in the consultation. They categorised this as a 'relational' factor deciding the doctor's use of the computer. Another qualitative study reported the patients' desire to view some of the information stored in their medical record but not the full content (Ridsdale et al., 1997).

Except for the concerns expressed about privacy and confidentiality, patients were generally not troubled by the doctor's computer during the consultation (Rethans et al., 1988; Terry and Francis,2007). Ornstein et al. (1994) reported the patients' appreciation about the availability of useful information as a result of the clinical computer systems and their contribution to better doctor-patient interactions.

2.4.6 Improved consultation tasks

The introduction of the computer has been linked with improved effectiveness of the consultation tasks (Ash et al., 2005; Schade et al.,2006) . The computer has now become an increasingly integral constituent of the consultation process. Introduction of the computer has also advanced the practice of evidence-based medicine (Watkins et al., 1999); by storing and improving accessibility to the information representing the evidence.

As a result of EPR use, data recording has become more comprehensive. The improvement of this and the quality has contributed to the improvement of the consultation tasks associated with chronic disease management (Petri et al., 2006; Campbell et al., 2005). The EPR system embedded decision-support features can analyse existing information based on the recorded diagnosis, test results and symptoms to assist the clinicians (Gill et al., 2001). They are also increasingly used to carry out screening for certain diseases (Gill et al., 2003). In addition to supporting on-demand decision making, EPR systems can also trigger reminders based on recorded disease management plans or guidelines (Adams et al., 2003).

The efficiency of prescribing tasks has improved significantly as a result of computer use (Mitchell et al., 2001). Generating repeat prescriptions has become faster and more reliable. Computerised prescribing has reduced errors and features like drug interaction and contraindication warnings have improved patient safety (Schade et al.,2006; Morris et al.,2005). The SCHIN survey in 2000 (Pemberton et al.,2003) presents (box 2.6) prescribing as the consultation task that has predominantly improved due to computerisation; 99.8% and 90.6% used the clinical systems for repeat and acute prescribing respectively. It also shows that more practices use computer systems for data collection for annual reports (89.3%) and the electronic patient record is now more widely used during the consultation (73.4%).

Considering the decision making support from the computer systems, clinicians have also indicated that drug interaction alerts as the most useful functionality. A recent review done by Kawamoto et al. (2005) identified that 68% out of 70 trials have reported improvements in clinical practice as a result of using the decision support tools.

- Repeat prescribing
- Acute prescribing
- Viewing clinical data
- Receive and view clinical data
- Data collection for annual report
- Referral letters
- Appointments
- Searches audits
- Maintenance of practice formulary
- Development of protocols
- Use of protocols
- Viewing clinical CD ROMs
- Emails
- Call and recall
- Audit
- Entry of clinical data
- Clinical records

Box 2.5: Application of clinical computer systems – based on the 1996 and 2003 SCHIN surveys

2.4.7 Medical record

The fundamental function of the EPR system is to facilitate the maintenance of the medical record containing the patient's medical history and health events. From its origin the medical record has been designed to act as a powerful external memory. Furthermore it provides a structure and context to assist the reasoning. It helps the user to organise the information and to construct a longitudinal case history for the patient. The success of the consultation and in general the ability to deliver the appropriate care in a timely manner often depends on the clinician's access to patient information via the medical record (NHSexecutive, 2000)

Despite the increased emphasis on the patient's psychological and societal attributes the medical record has largely remained as a record-keeping system for the biomedical attributes of the problem. It provides mechanisms to efficiently record data about diseases, investigations and test results using coded data with no specific provisions for holding items describing the patient's social context such as expectations, concerns, beliefs and other social circumstances. The General Medical Council (GMC) guidelines on good medical practice indicate the expected purpose of the medical record within the clinical consultation and interactions with the medical record (GMC,2009):

1. Recognise and work based on the competence
2. Prescribing and repeat prescribing based on adequate knowledge about patients health and usefulness of any treatment
3. Provide treatment based on best available evidence
4. Alleviate patient's pain and distress regardless of the possibility of a cure
5. Respect patient's right to a second opinion
6. Maintain clear, accurate and legible records. These should include;
    - Clinical findings
    - Decisions
    - Information given to patient
    - Drugs prescribed
    - Other treatments and investigations
7. Make records at the same time as the event or as soon as possible afterwards
8. Make the information readily accessible
9. Take advice from colleagues
10. Make good use of available resources

Box 2.6: The GMC good medical practice guidelines relevant to clinical consultation and interactions with the medical record (GMC,2009)

The quality of the medical record is assessed mostly by the completeness and correctness of the structured data it holds (Jordan et al., 2004). In addition, Hassey et al.(2001) propose the validity and utility of the medical record as measures of quality. Spies et al., (2004) particularly report the limited utility of the medical record to review the decisions related to a patient's condition and examinations. Another study found accurate recording of blood pressure, yet under reporting of lifestyle advice.

A study by Pringle et al., (1995) compared the completeness and accuracy of medical records in four computerised general practices and found that electronic medical records have higher if not comparable levels to those on paper. However, it suggests that the number of topics covered and the richness of the data recorded to be less in the electronic record compared to paper records.

The narrative component of the medical records makes the reader more engaging. Free text in medical records is considered an effective way of transmitting the patient's story (Berg et al.,1998). Because of the personalised nature of the information captured in free text in the computerised medical record, some observed it as an unattractive, residual alternative to the paper record

(Rector, 1993; Greenhalgh,1999; '. In terms of usability there are tradeoffs in the electronic version compared to its paper-based precursor; even though more free text entries could be stored and retrieved quickly, given that the size of the visual display unit and the area allocated for record display determines the amount of accessible information.

2.4.8 The current state of the computer-assisted consultation

Elwyn (2004) presents the existence of multiple agendas and external elements defining the content, context and the expectations of the 'postmodern' consultation. The increased access to information resources such as the Internet, media, clinical practice guidelines, social networks, consumer organisations and so on have created a wealth of decision aids for the patient. In parallel the relationships a modern day clinician has with his or her patients are complex. In addition to the number of policies and guidelines defining the medical practice, clinicians now have to work in larger teams, need to be constantly aware of the quality of the data they record and at the same time engage with more knowledgeable patients.

The biomedical tasks of modern consultations are prominent and defined by decision-support software tools. Systems exist to assist disease management, drug dosing and prescribing and preventative care. However, their integration into the consultation workflow is poorly studied (Garg et al., 2005) . Coulter (2005) discusses the wishes of patients from the health services in the wake of the planned NHS reforms. She concludes that along with the free, improved access to health care services, patients also desire access to reliable information, for health professionals to acknowledge their views and express preferences and for them to be able to "*get the help they need to help themselves*".

The integrated care record introduced by the NPfIT means clinicians who record the data arising from the consultation also have to consider its potential use within the entire health service (Booth N, 2003). The current tendency for integrated care and networked healthcare essentially depends on interdisciplinary cooperation and access to information (Lenz, 2007). There are four key technologies within the NPfIT's information architecture that are closely associated with the modern consultation workflow. They can be represented using four products introduced into primary care; Business Process Modelling Notation (BPMN), Map of Medicine (mapofmedicine, n.d), PROforma (Sutton, 2003), and HL7(hl7,2005) .

Holman and Lorig (2000) describe that the change of emphasis from acute to chronic diseases has contributed to modify the general attitude of the health system towards its customers; inexperienced passive recipients have become expert co-partners. The wave of NHS reforms presented in the new millennium introduced the consumerist notion of the patient (Greener, 2003) . Those reforms aspired to introduce personalised care; *"services have to be tailor-made not mass-produced, geared to the needs of users not the convenience of producers"* (DoH, 2000).

The practice-based commissioning (PBC) policies which give general practitioners responsibility for purchasing services for their patients has added more pressures to the consultation process(DoH, 2004). It has influenced the decision making, particularly related to problem management and has infused a sense of competitiveness (Smith, 2005) . The increased size of the practice population, general practitioners getting further qualifications in specialist clinical areas (RCGP, 2005) and the growth of the primary healthcare team sizes (RCGP, 2003) have also made significant alterations to the general practice consultation process. The scope and complexity of problems managed within primary care have also increased (Eccles et al., 2002).

BPMN – A graphical modelling notation to represent the procedures associated with activities. Adapted to represent the complexity and diversity of clinical workflow processes. Activities composed of hierarchically arranged business process, process, sub process and tasks.

Map of Medicine– A web-based clinical information browser with a specialist knowledgebase and information for evidence-based medicine. Patient pathways with information 'nodes' linked to guidelines/protocols and contextual information. Logically related nodes represented as 'pages'.

PROforma– A declarative language for representing the care pathways, protocols and guidelines in a computer interpretable format. Options and conditions to support irregular nature of the clinical workflow sequences. Consists of tasks for plan, decision, enquiry and actions and associated task scheduling constraints.

HL7 – A clinical messaging specification to facilitate electronic information exchange between computer systems. Indicates participants, clinical statements and their association to provide meaning.

Box 2.7: The four key technologies introduced into the clinical consultation's information architecture

2.5 Observing the consultation

There are a considerable number of consultation analysis research methods ranging from direct real-time observation by an observer, analysis based on orthographies for the transcription of verbal interactions within a videoed consultation, to more sophisticated analysis of multiple facets based on video recordings. Furthermore, there have been a number of analysis approaches defined by the facets of the consultation being investigated, the level of detail called for and the anticipated application of the outcomes.

2.5.1 Consultation observation techniques

Consultation assessment techniques have for the most part contained a manual observation phase, chiefly due to the primary care consultation's intrinsic complexity and variability. One of the most influential studies by Byrne and Long (1976) based on an audio recording of about 2000 consultations resulted in introducing a new theoretical insight into the consultation process. Recording of consultations using a single video camera is widely used for summative assessment of consultation skills of trainee doctors (McKinstry, 2004). Some studies carried out comprehensive enquiries of doctor-patient communication using segments of consultations (Ventres et al., 2005; Gibson et al., 2005). Gibson et al. (2005) have investigated the multi-tasking aspects of the consultation by combining video and conversation analysis methods.

Compared to other observation techniques, video-based methods capture the interactions in greater detail and allow the preservation of the same range of details without any lessening (Leong et al., 2006; Coleman, 2000; de Lusignan et al.,2002; Grimshaw, 1982) . The traditional video based recording setup involved only a single video camera capturing a wide angle view of the consultation area. The interpretation usually contains behavioural and conversational analysis, based on subjective observation and coding (Sheeler et al., 2006).

The measures regarding the verbal and non-verbal interactions are usually derived from subjective observations and subsequent coding (de Lusignan et al., 2002; Moulene et al., 2007). Latest video-based consultation analysis studies have been utilising video tagging software applications to classify specific segments of the videos and analyse them in isolation or as part of larger collections (Pearce et al., 2006). These are particularly useful for identifying common interaction phenomena over a larger number of consultations.

The impact of the presence of video cameras on the consultation process has been established as negligible (Heinztman et al.,1993; Campbell et al., 2001). The use of cameras to observe real-life consultation has little impact on practitioner behaviour or patient satisfaction (Campbell et al., 1995)

2.5.2 Observing verbal and non-verbal interactions

Verbal interactions have been widely used as a surrogate for doctor-patient interactions. Measuring them has been proved to be reliable. Usually this involves categorising the meaningful conversation segments based on an agreed classification, or assessment based on a whole section of verbal interactions. In the Roter Interaction Analysis System (RIAS), each meaningful utterance is categorised under five headings based on the perceived purpose (Roter, 2002). The categories are; social, affective, structural, health and lifestyle. Analysis of these 'utterances' then focuses on the percentage of verbal communications occurring under each category.

As discussed earlier, the non-verbal component also became recognised as an imperative communication facet. Early investigations into non-verbal behaviours were mainly done by reviewing video recordings. Studies that employed this technique reported difficulties due to the lack of sufficient details to recognise non-verbal interactions, the subjective nature of it and the time required (Caris-Verhallen et al., 1999).

2.5.3 Observing computer-assisted consultations

Most observational studies reviewed in this literature search investigating the role of the computer in consultations have mostly considered the doctors as system users and generalised their patterns of behaviour as well as the corresponding reactions of the patients. The studies that have proposed frameworks describing the doctor, patient and computer interactions have done so chiefly based on consensus and judgements rather than using rigorous scientific methods or objective measurements (de Lusignan et al., 2003; Kurtz et al., 2003). When the studies analysed the functioning of the clinical information systems, qualitative methods were used (Kushniruk and Patel, 2004).

Review studies report a wealth of qualitative information with insightful presentations about the usefulness of the computer. However, there is little detail reported about the computer's precise influence on the consultation tasks (Sullivan et al., 1995; Mitchell et al., 2001). In Coleman's study on doctor-patient interactions and their associations with the computer, the computer was classified as a material feature of the environment (Coleman, 2000).

Observing the doctor's use of the computer, and the patient's behaviour, has been useful in recognising the psychological and social aspects of computer-assisted consultations (Weinger et al., 2004). Pearce et al. used a single camera setup to examine the sociological aspects of the computer-assisted consultations (Pearce et al., 2006).

Using a single camera has its limitations. It is not capable of recording sufficient information about the purpose of computer use and non-verbal interactions between the doctor and patient (Theadom et al., 2003). Increasing the number of cameras, with more focused coverage and capturing the screen activity separately have increased the ability to capture information useful for interpreting those interactions. Analysing the observation data linking different episodes of computer use with their influences on doctor-patient interactions could possibly indicate suitable patterns for computer use; those that are causing a minimal impact on patient-centred interactions (Birgitte, 1997).

Furthermore, there is a need for a theoretical basis for the consultation observation approach and analysis of its findings; it provides a conceptual framework to deduce the meanings of those observations and to recognise their implications (Warshawsky, 1993). de Lusignan et al. (2002) developed a new rating scale with eight steps combining existing theoretical frameworks, traditional consultation tasks and additional steps identified by reference groups, for nurse consultations in primary care. This included the tasks identified by Pendleton and Neighbour in their models, with additional items highlighting the evidence based practice and the resultant practicality issues (box 2.10).

1. Review records – check results, letters
2. Establish relationship
3. Ask questions and define patient's agenda
4. Jointly agree on the importance of the issues raised
5. Identify the items in patient's agenda that are modifiable
6. Agree a realistic and feasible management plan
7. Hand over the summary and agreed plan
8. Prepare for the next consultation

Box 2.8: A model designed to analyse patient-centred nurse consultation

2.6 Analysing the consultation to evaluate the influence of information systems

2.6.1 Information systems and their functions

Langefors (1963) introduces the concept of 'Information systems' as a technologically implemented medium to collect, store, treat and distribute information and to draw conclusions from them. This definition remains valid for modern day information architecture. Information systems domain is an applied discipline (Sidorova et al., 2008) . Its ultimate aim is to advance the practice. It is not a neutral component; it is an important factor in any business process. Therefore, it is imperative for the information systems related research to be attuned to a system's operating environment, and for the analysis and evaluation techniques to be comprehensive. Their outcomes should be contextualised by the theories relevant to the system's environment, and should be usable for system designing and constructive to enhance the system's uses (Lee, 2003)'.

It is important to appreciate that information systems are social structures. Their principal function is to facilitate the coordination of business activities and communication between them. Particularly when the functioning of the information systems is well-matched with frame and contextual factors such as organisational culture, communication patterns, cognitive processes, personal and professional values, they have produced positive outcomes (Jones et al., 2006; Massaro, 2005; Sabherwal et al., 2006)'. Users are particularly receptive to new systems that are sensitive to their decision making styles (Yarbrough et al., 2007).

2.6.2 Information systems in the consultation setting

Healthcare processes are information and knowledge reliant. They are preconditions for medical decision making; to formulate the question, evaluate the evidence and to apply the knowledge (Hawkins, 2005)' Garg et al. (2005) after conducting a systematic review of the clinical decision support systems, report on their influence to improve clinical practice and patient outcomes Each pass of the diagnostic-therapeutic cycle involves sequence of information exchanges (Bemmel and Musen, 1997) . Langefors categorises the information dealt with by systems as informative and directive, based on whether they are used for operative or strategic decision making respectively. Information is used for both purposes in the consultation.

The UK's national programme for computerisation (National Programme for Information Technology – NPfIT) aims to achieve a distributed information architecture. It has been working towards establishing a network consisting of interoperable information systems. The electronic medical record is the core information agent, and consequently the consultation becomes the key functional organisation. Therefore the successful integration of the information systems at the consultation level is a must for the development of resourceful healthcare information architecture (Lenz et al., 2005).

The effects of introducing information systems into processes and organisations are not always predictable (Berg, 2001) . This could be critical in consultation settings. Ideally general practice information architecture should enable the evidence-based practice of medicine while supporting the patient-centred delivery of care (Ammenwerth et al.,2004) . Instead of altering the consultation tasks around the functionality of the information system, users should be able to integrate the information system features into the usual consultation practice (de Lusignan, 2003) . The design, implementation and evaluation of information systems solutions should be aimed at achieving this.

2.6.3 Analysing the consultation tasks for Information Systems solutions

Abstracting features of the consultation that represent its practical facet and the theoretical values into an analysable model has the potential for supporting the development of an information systems solution to sustain a 'good' consultation. Coiera advocates the necessity to investigate the impact of information systems on the consultation from a broad sociotechnical standpoint (Coiera, 2004) . He argues that using a purely technical perspective has failed to recognise the inherent complexity of the practice of medicine.

2.6.4 System users

There is a crucial relationship between end users and their information systems. Nielsen (1993) represents this by saying "*using the system changes the users, and as they change they will use the system in new ways*". Arondi et al. (2002) define this notion of enabling the systems to adjust according to the different usages as "co-evolution" . Two patterns of co-evolution have been recognised; users discovering novel ways of using the systems to obtain the outcomes they desire which were not originally provided by the system and users building up some habitual interaction patterns through practice.

Cypher (1993) defines the end user as "*a person who uses a computer as part of daily work, but is not interested in computers per se*". The important facet that needs recognising is that end users' real needs and contexts within which they operate could be different, than those perceived by the system developers. The level of understanding system designers have about user needs is paramount for the success of any information system. When recognising the position of the doctor as a direct user of the EPR system, the concept of 'domain-expert users' discussed by Costabille et al. (2003) is relevant. Users, who are experts in domains different from computer science, but are using computer systems in their daily work are classified as domain expert users. It is vital to identify the tasks domain users accomplish with computer systems and their genuine needs that are not supported. In the latter case, system features might need modification or improvements.

2.6.5 Challenges in integrating information systems

The poor emphasis on usability of the EPR systems with respect to the structure of the clinical consultation has been recognised (Pearce et al., 2010). There is a possibility that the underlying root cause for this failure is linked to the unavailability of suitable analysis methods. The disparity between the ways the clinical system developers and the users comprehend the decision making, their goals and the relationships with the working environment have been recognised as the foremost challenges for the systems development projects in healthcare (Demeester, 1999; Leidner et al., 2006; Patel, 2000)'.

In contrast, there are also opportunities unique to general practice compared to other types of information systems design attempts. Due to the focused nature of primary care functions, the system's scope of use can be comprehensively captured (RCGP, 1999) compared to system development attempts in other domains. This is considered as one of the main factors that contributed to the successful and rapid computerisation in general practice, even compared to secondary care (Benson, 2002)

2.6.6 Evaluation of systems in health care setting

Thorough and widely accepted evaluation frameworks, if used sensibly based on the understanding of the real-world characteristics of the health care systems, should support the identification of their problems, suitable resolutions and analyse the outcomes (Ammenwerth et al., 2003). Moehr (2002) discusses the disadvantages of adopting an objectivist approach which was originally developed for simulation-based evaluations, to evaluate real information systems in health informatics. He presents the complexity, rapidity of change and possibility of existing in different variants as reasons for this incompatibility. His recommendation is to use a combined approach and to introduce quantifiable subjectivist approaches. Likewise, Davis and Taylor-Vaisey (1997) present the need for analysing the information technology innovations associated with healthcare from a contextual and holistic viewpoint.

There is a need for evaluation methods particularly suitable for health care systems (Westbrook et al., 2004). Such analytical understanding requires systematic evaluations of the work processes. In the Software Engineering domain, process modelling meets this demand.

2.6.7 Process modelling

Information representation is a fundamental element of information systems discipline. A process model generally represents the process steps of a procedure graphically from start to end together with their associated decisions. The modelling approach used for presenting the processes should be germane to the stakeholders who will be using the models and appropriate to the system under investigation (Lindland, 1994; Davies et al., 2006). Shank (1999) proposes three aspects that should be considered for process representation; grammar for representation, structure and content.

There are widely used process analysis techniques, methodologies and tools. There are templates useful for identifying the most appropriate modelling approaches (Buchnan, 1998). In situations where none of the existing modelling techniques appears to be versatile enough to represent system needs, the recommended strategy has been to assess the possibility of extending a suitable aspect of a popular modelling technique and constructing a tailored version (Saboor et al., 2005). Identification of the correct level of process mapping methods or extending existing approaches are common challenges in many domains as with health care (Reijers, 2003).

2.6.8 Business Process Modelling (BPM) and Unified Modelling Language (UML)

Business processes modelling (BPM) approaches are widely used in software engineering and systems engineering domains (Jacobson and Bylund, 2000) . This is the systematic process of representing the existing processes of an enterprise so that they can be analysed and improved in order to enhance the overall operation (Holt, 2009). They are commonly used to obtain analysable frameworks (Blanchard and Fabrycky,2005; Haug,2001)'. Process analysis activities informed by business process models are useful in software development projects for business process redesigning, re-engineering (BPR), improvement or system design initiatives.

Business Process Modelling Language (BPML) has been developed as a notation capable of joining together the features of widely used modelling approaches (bpmi, n.d.). This includes the unified modelling language (UML), a well established general purpose modelling notation (Booch et al., 1999). The ability of the UML to facilitate developers in gaining insight into complex processing steps has been acknowledged. It can be particularly useful in the identification of problem areas in business processes (Knape et al., 2003). The UK government's e-Government Interoperability Framework (e-GIF) recommends the UML as a modelling and description language (Cabinetoffice, 2009). In fact the government's information architecture and message specifications have been developed as a set of UML models (Cabinetoffice, 1999).

2.6.9 Modelling healthcare activities

Within a business context, activities can be often defined distinctively; they are procedural in nature and usually performed repeatedly with fewer variations in the process structure. In contrast, modelling clinical activities are complex. Clinical decision making is inherently complex. The existence of different diseases, health conditions, patient expectation, consultation styles, local needs and so on, results in unpredictable complex clinical processes.

Unified Modelling Language (UML) and other similar Business Process Modelling Notations (BPMN) have been the most widely used information system analysis techniques in the healthcare domain (Holt, 2009). Due to the capability of the BPMNs to model both simple and complex business processes, they are particularly popular in development of electronic care pathways (Benson, 2005). It has attractive features for both system developers and clinicians; it is simple to interpret and also has the capability of producing executable technical output.

Process modelling has been piloted as a supporting technology for passive clinical decision making in health care process. Object oriented models based on the structures of treatment patterns and therapeutic histories, and electronic medical record functionalities have been utilised to improve efficiency of guidelines, and to assess optimal use of the medical records (Ebrahiminia et al., 2005) The models have also been utilised for the development of new techniques for representation of guidelines, enabling them to be sharable and interpretable by software applications. Rosen et al. (2009) have used a process map to visualise and improve the clinical trial work flows. They found this technique an effective means for recognising any diversions of the process flow from the designed operational paths, errors, oversights and ambiguities. The resolutions to rectify those issues were also recognised by analysing the process maps.

One of the best applications of computer interpretable clinical process representation methodologies is the 'Proforma' guideline modelling language (Sutton and Fox, 2003), developed by Cancer Research UK. It focuses on evaluating the clinical decision against the evidence base, a task commonly performed in primary care in the scenarios of drug prescription, risk assessments and referrals. Process modelling has been useful for evaluating redesign heuristics in a mental healthcare case study (Vullers et al., 2005). The approach has enabled it to identify new opportunities for improving patient intake procedures.

2.6.10 UML in healthcare

In a health care setting, UML has been used as a process modeling tool to assess clinical processes (Saboor et al., 2005) and to gauge and compare the influence of different information system solutions (Ammenwerth et al., 2003) . Knape et al. (2003) reports on the potential in manipulating the presentation characteristics of electronic medical records based on a comprehensive process understanding. They used UML to represent the decision making tasks.

Process modelling features of the UML, have been frequently used for representation of clinical practice guidelines. Activity diagrams and class diagrams have been the preferred diagram type in most occasions, though in some instances the optimal presentation of workflows has been achieved only after manipulating certain diagram features to make them compatible with the clinical context. Shiki et al. (2008) have used the UML to extract the core and distinctive functions of a hospital cancer registration process. They have used a combination of UML Use Case, activity and class diagrams to describe the work flow of the existing system. Activity diagrams were used to identify the process steps of each department, Use Cases to define the role of each department within the hospital and the class diagrams to represent the information flow.

Lyalin et al. (2005) also reports the use of UML activity diagrams to represent a cancer registration process. However, to represent the complexity of the registration tasks they have extended the conventional activity diagram notation; adding a timeline feature, durations and responsibilities for individual activities and annotations. Those enhancements have improved the visual clarity of the diagrams and enabled them to represent more process concepts. Outputs of UML process models in XMI (XML metadata interchange) formats have been used for automated generation of guidelines (Knape et al., 2003).

2.6.11 Theoretical views on influence of information systems

There is a significant relationship between the multitude of approaches used for process modelling and the theoretical frameworks used as the basis for those abstraction endeavours. System-based conceptual frameworks and clarifications supported by information system theories benefit the investigations on process structures and changes in both micro and macro levels.

Adaptive Structuration Theory (AST) which is an extension of the 'Structuration Theory' presents a framework to analyse relationships between the user interactions and the information systems (Kaplan et al., 2004). AST uses the concept of 'structuration' to .represent the idea of dual relationship between the systems and structures. Interactions between them result in ongoing cycles of production and re-production of each other. This presents the idea of structures of an innovation penetrating the user society, and that the social structure in turn influences the innovation's original intentions. This gives us the framework to identify how the electronic medical record; as an innovation has penetrated the consultation; as a social system.

The Actor Network Theory (ANT) is another applicable framework (Latour, 2005; Lehoux et al., 1999)'. It explores the social, technical, organisational and technical structures based on the view that components of each structure have a network of relations. It considers the relationships among the concepts as well as the things; it is also known as the 'material-semiotic' method. Accordingly, the medical record plays a role of an essential integrated component within the 'material-semiotic' interaction between doctor and the patient. It represents both the material aspects of the relationship either in the form of an electronic and/or paper record as well as the conceptual dimensions such as patient expectations and doctor's perceptions. It also argues that both the human and non-human elements should be explained in the same terms. This is due to the rationale that the characteristics of each component are not inherent, but defined by a network of relations, i.e. actors take their shapes based on features of the relationship. Therefore, outside the consultation setting doctors, patients or medical records are not apparent as individual actors or networks. It is the material-semiotic networks linking them that form a coherent whole within the consultation.

Chapman presents information system innovations in healthcare based on the systems thinking theories (Chapman, 2002). The underlying approach of systems thinking is the abstraction of a problem domain into simpler representations, in order to understand how different constituent parts influence each other within the whole (Skyttner,2006). Systems thinking is a holistic approach; concerns arising from different standpoints are contextualised into a larger view and it promotes organisational communication. The concepts this perspective model introduces regarding the discovery of solutions through exploration, process improvements, learning from what is productive and innovating are pertinent to the problem domain of this thesis.

The value sensitive design (VSD) approach covers most of the notions discussed in the above theories and provides a potential approach for developing information systems that are easily adaptable to user environments (Friedman et al., 2006). VSD is a theoretically grounded approach for the design of information system solutions considering that human values are important to the systems environment (Box 2.9). It has features that are particularly attractive in consultation settings; it is interaction oriented, considers the values of the users who do not directly interact with the system but are affected by it (e.g. patients) and it recognises the distinction between usability and human values. Especially the separation of usability and values acknowledges the likelihood of having design features that may not be the most constructive in terms of usability, although with useful characteristics to enhance the patient-centeredness.

- **Interaction oriented** – The goals of the system's stakeholders are considered rather than the values linked to the technology or the social forces.
- **Includes both direct and indirect stakeholders** – Consider the individuals or groups of users who directly interact with the system and other users who are affected by the system.
- **Proactive designing** – The ability to influence a system development exercise throughout its design process.
- **Wider coverage** – It is possible to incorporate values covering broader issues – social, cultural, organisational and so on.
- **Iterative and integrative development** – Investigations covering numerous aspects and their findings can be incorporated iteratively.
- **Enlarges the scope of values** – Can include values from a multitude of environments, going beyond the design context and also consider belief systems such as conventions and personal values.
- **Distinguishes between usability and human values** – Ability to analyse and incorporate desirable functional characteristics and those pertaining to human values.
- **Acknowledges variations in conceptualisation** –More abstract values could be acceptable universally, more concrete values would have number of cultural variations. The interpretation of the values depends on the culture and the time.

Box 2.9 Features of the Value Sensitive Design approach (Friedman et al., 2006)

2.7 Critical appraisal of the literature review findings and implications

The majority of the studies that have looked into the characteristics associated with the computer assisted consultation are mostly discussing about the influence of the computer on the consultation at a macro level. They mostly discuss about the patient's perception about computer use or compare changes of various overall performance indicators. There is a dearth of investigations focusing on the influence the EPR system has on individual consultation tasks, and how computer use patterns change with different system design features. And more importantly a very few studies have attempted to investigate the influence of system characteristics to the subtle social interactions. Although the earlier investigations have considered the computer as a tool to assist consultation tasks rather than an influential entity, more recent publications have acknowledged the possibility of having triadic relationships; where the doctor, the patient and the computer are having similarly prominent roles. Some researchers have even considered the ability the computer has to modify the consultation agenda. This review further establishes the transformation of the traditional one-to-one consultation to a triadic form as a result of the increased focus on computer involved interactions.

Literature associated with the consultation tasks and theories suggest an increment of the scope and complexity of the primary care functions. The biomedical tasks related to the management of chronic diseases have increasingly become prominent. According to a number of authors, and published guidelines these functions seem to be readily supported by the existing primary care information architecture.

Regardless of the difference between the publications in terms of their perspectives on the consultation processes, all authors seem to consider the consultation as a complex social interaction. A number of studies that discuss about the consultation tasks acknowledge the co-existence of clinical and psychological elements. This literature review findings also imply the influential nature of the doctor-patient relationship. A number of investigations have attributed it as a measure of a 'good consultation'. Despite the dissimilarities between the early interpretations of the successful consultation, the latest and more universally accepted definitions emphasise two main notions; holistic care and patient centeredness.

Also, there are attempts by a number of scholars to consider the contextual elements associated with the consultation's conduct. The majority of such discussions have considered a multitude of frame and individual factors brought into the consultation by both the doctor and the patient. Furthermore there are a few studies and theratical models that have considered the influence of the physical environment. In overall, influential contextual elements discussed in the literature can be classified in to three main categories; (1) individual, (2) organisational, and (3) environmental factors. Studies that have discussed about the individual factors have primarily considered the doctors' and patients' societal, professional, psychological or cultural values and goals. Performance measurements, guidelines and standards introduced at health care system level or by professional bodies form the organisational factors. Studies that have looked into the environmental factors have mostly discussed about the physical and process attributes.

Literature associated with the consultation observation techniques suggests the need for having theoretically grounded approaches. There is also a demand for having investigation tools capable of supporting technical solutions development that can blend in easily with the social aspects of the consultation. Although there are information system theories that give prominence to user values, and how the needs of direct and indirect users should be studies, there is lack of published literature exploring those aspects linked with clinical system developments.

According to the reviewed literature, the mutual effect information systems have on the social aspect of the system is widely accepted. Researchers have also discussed on the contribution of holistic approaches; those that consider both the system requirements and the user values when designing information system solutions. However there is a lack of research focused on developing consultation observation techniques to support information systems development agenda. Though there are studies focusing on the usability aspect of clinical systems, none has investigated the possibility of capturing an all-inclusive view of the clinicians' interactions with the computer, the precise impact the EPR system is making on the consultation process in a way to assist system designing or evaluation.

Furthermore, a number of researchers have discussed how process assessments, their abstraction and analytical representation could benefit to elucidate complex, interrelated and often unpredictable interactions that take place in a consultation. The author came across a number of researches where process modelling has been utilised for clinical process improvements; however, there are no studies looking into its implications for improving computer-assisted consultation tasks. When the literature on the existing theoretical models of the consultation is considered, the need for a acknowledging the implications of computer use and the skills required for its integration is also evident.

This review also recognised the scope for improving consultation observation methods, the need for establishing a framework to interpret findings and an approach to present them formatively. A constantly raised concern by many authors is the lack of mutual-awareness between clinicians and system designers; there is a need to establish an inclusive understanding about the consultation and the association it has with the context within which consultations are conducted.
An increased number of studies have also looked into the notion of shared decision making; promoting the participation of both doctor and patient. Those publications admit the influence of knowledge and expertise individual participant brings into the consultation. However, studies looking into the EPR system characteristics have fail to acknowledge this increased patient participation.

Within the universally computerised UK general practice, the EPR system is the most directly involved essential and influential information system agent. Its overall influence has been widely acknowledged in the literature. Nevertheless, there is a dearth of publications about the importance of clinicians actively integrating the EPR into the consultation. This review also indicates a deficient in theoretically informed insight or conceptual clarifications about the mutual dependency between the information systems and the soft systems in the primary care context.

Publications included in this review related to process modelling indicate the capacity of UML-based process models to describe inter-dependent characteristics of interactions. There are also publications suggesting, that if based on accurate process abstractions, UML models can provide insight into the influence of technology in the computer-assisted consultation. Further investigations are needed to establish the most appropriate UML modelling approach and to develop a fit for purpose modelling specification.

2.8 Summary

The review described in this chapter signifies the multi-disciplinary character of this research. The discussions in this chapter also indicate the demand for a mutually compatible, theoretically informed and fit for purpose research design covering both consultation and information systems perspectives. There is also a need for establishing a consultation analysis framework to interpret and draw conclusions from the observational findings. Consequently, three principal elements can be identified as central to this research approach;

1. Recognising the elements of consultation theory and practice pertinent to the research objectives
2. Reviewing the state of the art of consultation observation techniques
3. Deriving a theoretically informed task and process abstraction strategy

This chapter indicates the pragmatic factors associated with the acceptance of system features. For example, certain design features were accepted as essential and have improved over time, while some features were considered as optional or discarded as impractical. Such understanding is useful for interpreting the observational data on doctor-computer interactions, their representation in process models and analysis. Findings in this chapter imply that analysing the EPR system acceptance or selection process may point out the compatibility issues between system design features and the characteristics of the consultation process. This understanding is important for developing the technical method of this study, and the subsequent comparative evaluation of the EPR system design features involved in doctor-computer-patient interactions.

Findings from this chapter validate the primary research hypothesis in a general level, and more importantly signifies the need for further investigations to asses its exact status. This chapter also recognises the dearth of research with sufficient power to assess the eight sub hypotheses considered in this study.

CHAPTER 3

Models of the clinical consultation and approaches to observation

3.1 Chapter introduction

> "The essential unit of medical practice is the occasion when, in the intimacy of the consulting room or sick room, a person who is ill, or believes himself to be ill, seeks the advice of a doctor whom he trusts. This is a consultation, and all else in the practice of medicine derives from it." *Sir James Calvert Spence (1953)*

The encounter that takes place between doctor and patient during a consultation has been subject to much detailed study. Consultation models introduced over the last 60 years have incorporated a multitude of abstraction frameworks; doctor-patient relationship, consultation outcomes, patient perspectives and task or process- oriented approaches. This chapter summarises the prominent models in order to gain a theoretical insight into the clinical consultation. By doing so, the position of the first three sub hypotheses (Hs1-Hs3) associated with the consultation observation approaches and contextual factors linked to the consultation are considered. This chapter also explores the qualitative aspects of doctor-patient social interactions in order to gain the background information related to the sub hypothesis Hs6, which primarily considers the aspects of patient centeredness.

This chapter investigates the multiple facets each of the theoretical model represented, in order to recognise the objectives, perspectives and priorities associated with the time periods they represent. Their findings are utilised to explore the progressive changes in the consultation characteristics and their contexts. Discussions on the models are presented in a time-oriented manner; representing the aspects of the consultation that were explored notably in the time period they represent. Attempts are also made in this section to establish an overview of progressive developments in consultation theory, practice and analysis approaches. In that respect, this chapter provides the theoretical basis. Implications from this section consequently support establishing a framework for representing and analysing the influence of the information systems on consultations.

This section also explores the observation approaches used by number of studies followed by a detailed discussion about the audio and video recording based approaches. Their technical profiles, underlying deign objectives and implications to practice are also discussed. The final sections focus primary on the approaches used for coding and interpretation of the observation findings and then to evaluate the position of the related hypotheses together with additional work needed. Discussions in this chapter review the progressive changes of the observation techniques to rationalise the observation apparatus developed for this study, primarily aimed at testing the full range of hypotheses considered in this study.

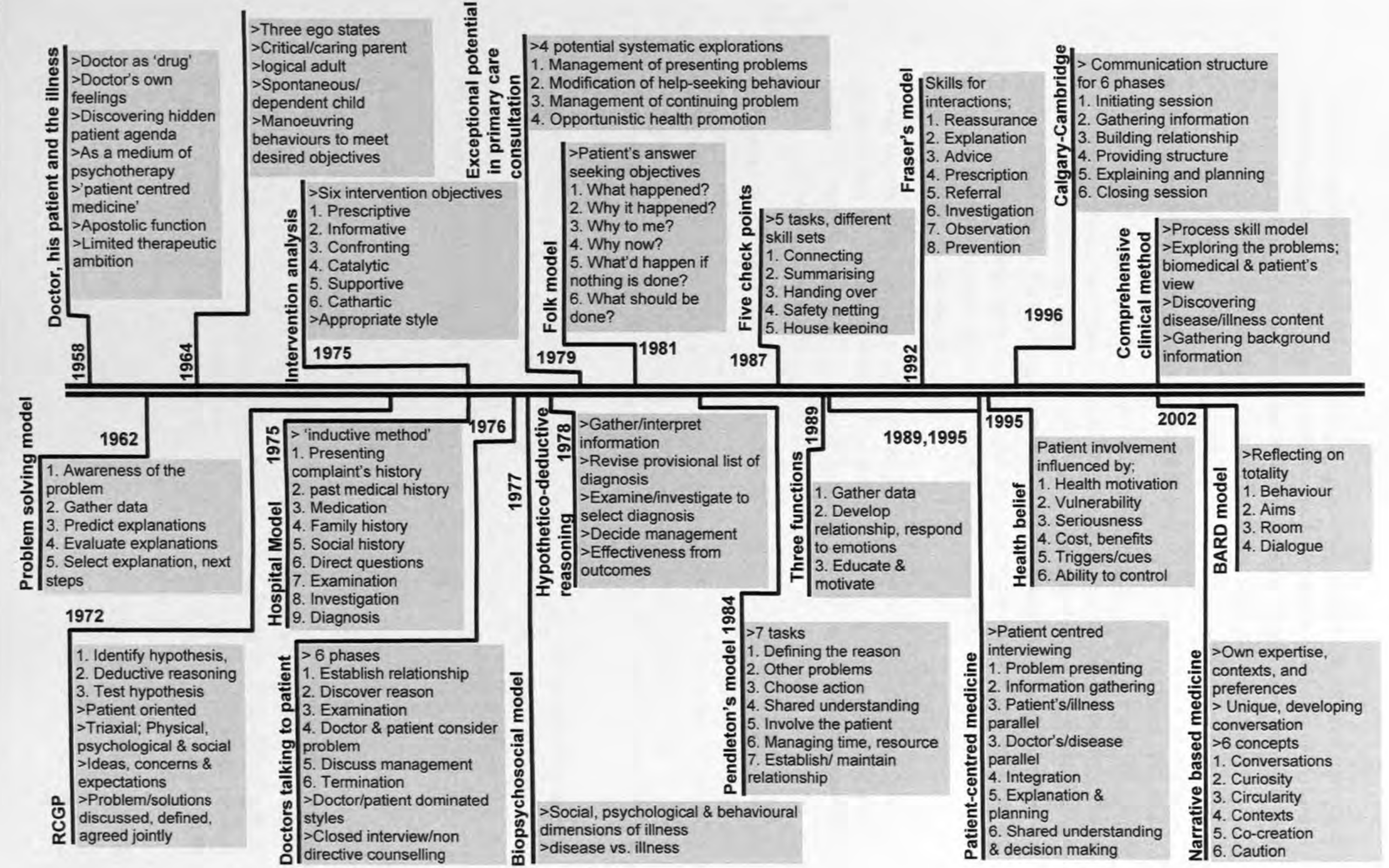
3.2 Consultation models and their progressive changes

Table 3.1 lists the theoretical frameworks considered for this investigation. Some of those included here have not been commonly referred to as theoretical models but rather as models for interaction analysis, as frameworks representing general consultation episodes in clinical environments (e.g. biomedical model) or theories focused on specialised fields such as psychology (e.g. intervention analysis). However, their inclusion in this review is chiefly based on the fact that they have been utilised for consultation observation studies; for development of assessment instruments or to analyse findings.

Consultation model/framework	Year	Creators/authors
Doctor, patient and the illness	1957	M Balint
Problem solving model	1962	H Gelat
Transactions analysis model	1964	E Berne
Physical, Psychological and Social approach	1972	RCGP
Intervention analysis	1975	J Heron
Hospital model	1975	
Doctors talking to patient	1976	P Byrne, B Long
Biopsychosocial model	1977	GL Engel
Hypothetico-deductive Reasoning/biomedical	1978	
Exceptional potential in consultation	1979	N Stott, R Davis
Folk model	1981	C Helman
Pendleton's model	1984	D Pendleton, T Schofield, P Tate
Five check points	1987	R Neighbour
Exceptional potential -revisited	1989	J Middleton
Three functions	1989	S Cohen-Cole, J Bird
Patient-centred medicine	1989,95,2003	M Stewart, D Rotar, I McWhinney
Fraser's clinical method	1992	R Fraser
Health belief	1995	P Tate
Calgary-Cambridge	1996	S Kurtz, J Silverman et al
Comprehensive clinical method	2002	S Kurtz, J Silverman et al
Narrative based medicine	2002	J Launer
BARD model	2002	E Warren

Table 3.1: Consultation theoretical models/frameworks frequently used for research, training and education

Figure 3.1 (next page): Consultation theoretical models and their key characteristics mapped onto a time-line



1958
Doctor, his patient and the illness
>Doctor as 'drug'
>Doctor's own feelings
>Discovering hidden patient agenda
>As a medium of psychotherapy
>'patient centred medicine'
>Apostolic function
>Limited therapeutic ambition
1962
Problem solving model
1. Awareness of the problem
2. Gather data
3. Predict explanations
4. Evaluate explanations
5. Select explanation, next steps
1964
>Three ego states
>Critical/caring parent
>logical adult
>Spontaneous/ dependent child
>Manoeuvring behaviours to meet desired objectives
1972
RCGP
1. Identify hypothesis,
2. Deductive reasoning
3. Test hypothesis
>Patient oriented
>Triaxial; Physical, psychological & social
>Ideas, concerns & expectations
>Problem/solutions discussed, defined, agreed jointly
1975
Intervention analysis
>Six intervention objectives
1. Prescriptive
2. Informative
3. Confronting
4. Catalytic
5. Supportive
6. Cathartic
>Appropriate style
1975
Hospital Model
> 'inductive method'
1. Presenting complaint's history
2. past medical history
3. Medication
4. Family history
5. Social history
6. Direct questions
7. Examination
8. Investigation
9. Diagnosis
1976
Doctors talking to patient
> 6 phases
1. Establish relationship
2. Discover reason
3. Examination
4. Doctor & patient consider problem
5. Discuss management
6. Termination
>Doctor/patient dominated styles
>Closed interview/non directive counselling
1977
Biopsychosocial model
>Social, psychological & behavioural dimensions of illness
>disease vs. illness
1978
Hypothetico-deductive reasoning
>Gather/interpret information
>Revise provisional list of diagnosis
>Examine/investigate to select diagnosis
>Decide management
>Effectiveness from outcomes
1979
Exceptional potential in primary care consultation
>4 potential systematic explorations
1. Management of presenting problems
2. Modification of help-seeking behaviour
3. Management of continuing problem
4. Opportunistic health promotion
1981
Folk model
>Patient's answer seeking objectives
1. What happened?
2. Why it happened?
3. Why to me?
4. Why now?
5. What'd happen if nothing is done?
6. What should be done?
Pendleton's model 1984
>7 tasks
1. Defining the reason
2. Other problems
3. Choose action
4. Shared understanding
5. Involve the patient
6. Managing time, resource
7. Establish/ maintain relationship
1987
Five check points
>5 tasks, different skill sets
1. Connecting
2. Summarising
3. Handing over
4. Safety netting
5. House keeping
1989
Three functions
1. Gather data
2. Develop relationship, respond to emotions
3. Educate & motivate
1989,1995
Patient-centred medicine
>Patient centred interviewing
1. Problem presenting
2. Information gathering
3. Patient's/illness parallel
3. Doctor's/disease parallel
4. Integration
5. Explanation & planning
6. Shared understanding & decision making
1992
Fraser's model
Skills for interactions;
1. Reassurance
2. Explanation
3. Advice
4. Prescription
5. Referral
6. Investigation
7. Observation
8. Prevention
1995
Health belief
Patient involvement influenced by;
1. Health motivation
2. Vulnerability
3. Seriousness
4. Cost, benefits
5. Triggers/cues
6. Ability to control
1996
Calgary-Cambridge
> Communication structure for 6 phases
1. Initiating session
2. Gathering information
3. Building relationship
4. Providing structure
5. Explaining and planning
6. Closing session
Comprehensive clinical method
>Process skill model
>Exploring the problems; biomedical & patient's view
>Discovering disease/illness content
>Gathering background information
2002
BARD model
>Reflecting on totality
1. Behaviour
2. Aims
3. Room
4. Dialogue
Narrative based medicine
>Own expertise, contexts, and preferences
> Unique, developing conversation
>6 concepts
1. Conversations
2. Curiosity
3. Circularity
4. Contexts
5. Co-creation
6. Caution

There are significant conceptual, structural and contextual elements introduced by the earlier presented consultation models. Their implications need to be interpreted together with explorative approaches adopted or dimensions analysed by the respective models. The following sections discuss the consultation features that are linked to the research framework of this study.

3.2.1 Consultation tasks and associated interactions

The conventional consultation models used for teaching medical students primarily consisted of four key tasks (Kurtz et al., 2003); (1) performing history, (2) examination, (3) diagnosis and (4) treatment. The problem solving model proposed by Gelat (1962) had similar elements for gathering data. However, the last two segments of 'diagnosis' and 'treatments' in the traditional model have been expanded into three items, with increased emphasis on the selection process. Byrne and Long's model is in fact comparable to the traditional model, although the former has two additional stages to mark the initiation and termination.

Certain models present the position of the doctor based on their role in manoeuvring interactions; Neighbour and Balint interpreted the doctor's role as a 'catalyst' and as a 'drug' respectively. Particularly, Neighbour's presentation of the clinician as a 'catalyst' corresponds to the immediate effect doctor-patient interactions has on an effective communication.

Psychologically oriented models such as the Folk, Intervention analysis, Health belief and Transaction analysis models focused on the rationale for interactions. Models discussing the narrative nature of consultations have similar perspectives. Task oriented models are essentially proposing objectives for interactions; for example, tasks aimed at gathering data, evaluating explanations and discussing management. They actually represent the constituent interactions that contribute to those objectives.

When the diversity of the chief elements emphasised by earlier mentioned models is considered, the presentations around the interactions are the commonest. In fact, establishment of general practice as a separate area of expertise has been linked to this unique value attributed to the doctor-patient interactions (McWhinney, 1997).

3.2.2 Consultation initiation

Ascertaining the patient's reason for attendance is often recognised as an initial task. Initiating the consultation with open-ended questions is a common feature seen in models promoting patients' participation. The Calgary-Cambridge model particularly emphasised on the opening sequence of consultations. Byrne and Long identified that in 5% of the consultations they analysed the goals of the GP or the patient were not clearly expressed. There is a challenge in apportioning sufficient time for the initiation phase of the consultation and at the same time assuring that the consultation is not taking longer, which could impact on the remaining phases or any subsequent consultations.

In contrast, Balint mentioned the possibility of doctors deciding to reject the list of offers a patient brings to the consultation after clarifying them. This process could have two extremes; some doctors may reject what the patient offers by not listening or without acknowledgement, while others may listen attentively and encourage the patient to express concerns and expectations.

By the time Pendleton's model was introduced, this initial stage of consultations for identifying the reason for attendance seems to have been established as a distinctive and quite imperative component. This phase was earlier mentioned in both models presented by Stott et al. and Byrne et al.

Starfield et al. (1981) argued that the ability to perform a diagnosis and other consultation tasks related to management and assessments have a significant dependence on the consultation initiation. Some suggested it as the most challenging and rewarding component of the consultation (Hodson,1967). Patients getting the opportunity to fully explain their reasons for seeking doctor's help at the beginning of a consultation may possibly prevent new problems surfacing in the later stages and assist the doctor in maintaining a better flow (Silverman, 2005).

3.2.3 Therapeutic relationship

Continuity of the doctor-patient relationship is significant for patient care. This was highlighted by Balint in the 1950s, and has been reiterated in the form of consultation objectives in a number of models ever since; for example, by Berne in the1960s, Byrne and Long 1970s, Pendleton in the 1980s and Calgary-Cambridge in the 1990s. Over the years more contextual elements have been emphasised by the theoretical models, giving prominence to long-term relationships.

Balint acknowledged the importance of a GP using his or her own feelings to appraise the progress of the consultation constructively – a process termed 'countertransference' in psychology fields. The notion of 'doctor as drug' and the therapeutic ambitions doctors present were seen as a responsibility in the Berne's model. This dimension of 'help-seeking behaviour' is parallel to the Berne's interpretation of the patient as being in a childlike ego state. In the late 1980s Neighbour deduced the role of the clinician as a catalyst, rather than a 'drug' as Balint viewed in the late 1950s. He defined consultation as a 'journey' rather than a 'destination'.

Patients generally prefer a relationship-based continuity of care (NPCRDC,2005). Most patients prefer to see their familiar GP (Schers et al., 2002). They presuppose their usual GP to be cognisant of their 'story'. This is particularly true for older patients and those having chronic conditions and is associated with patient satisfaction (Bower et al., 2003). However, this is challenged by the ever-increasing complexity of health service provisioning (Guthrie and Wyke, 2000); for example, as a result of factors like the larger multidisciplinary teams, specialised health care professionals, out of hours access, web-based services and organisational intercessions.

In the patient-oriented approach doctors assist the patients to make an informed choice (Stewart, 2003). In the doctor-centred style doctors engage as experts advocating the treatment plan they evaluated as the best for patients (figure 3.2). This choice given to patients could also be deduced as giving them power for decision making. Shared decision making is essentially a middle path that lies between those two extremes, where both patient and doctor, based on the available information, by evaluating each other's interpretations and preferences jointly make decisions (Charles et al.,1997).

Byrne and Long reported incidents where clinicians discussed disease management options with their patients. Pendleton specifically proposed to involve patients during this phase of the consultation and the need for achieving a shared understanding. He proposed tasks with aims such as 'shared understanding' and 'involve the patient'. The Three functional approach (Cohen-Cole, Bird, 1989) also mentioned this notion when it explained the requirement to 'develop a relationship'. The mid 1990s Health Beliefs model represented the influence of the patients' perception on the behavioural responses to the clinicians' proposals and the willingness to share the responsibility (Glanz et al., 2002). This has integrated concepts pertaining to Engle's three dimensions of illness.

The patient's awareness or understanding of the clinical practice is associated with the certainty of patient involvement. This is also linked with the idea of patient's 'social reality' described by Kleinman. Wennberg (2002) discussed this information deficit, which could in fact hinder the patient's participation in the consultation process and suggested the need for additional mechanisms to assist the patient. He identified such tools as 'patient decision aids'.

Elwyn presented a model with a list of competences expected from the clinician to facilitate shared decision making (Elwyn et al., 1999). Enabling patients to acknowledge and act in their rightful role in the decision making was the standpoint presented by this model (box 3.1).Inevitably, other facets of the consultation context including the nature of the problem/s discussed, patients' age, their education levels, doctors' style of consulting, available time and so on could support or hinder the shared decision making process (McKinstry, 2000).

1. Defining the problem with patient – implicit or explicit involvement
2. Explore ideas, fears and expectations associated with the problem and treatments
3. Listing the options and equipoise – finding the balance based on the informed benefits and harms
4. Checking understanding – of information and reactions to the available options
5. Check process – acceptance of process and decision making role preference
6. Decision making – discussing or deferring decisions
7. Review arrangements – follow up options

Box 3.1: Model for shared decision making

3.2.4 Patient centeredness and holistic approaches

Differentiation of consultation styles based on the effort made by the doctor to understand patients' objectives was first recognised by Balint (1969). He used the term 'patient-centred medicine' when he tried to present the need to move away from illness-centred 'traditional diagnosis' approaches. A more detailed approach to these two styles has been presented by Byrne and Long (1976). Pendleton also established the need to address patients' ideas, anxieties, expectations and the impact of the problem.

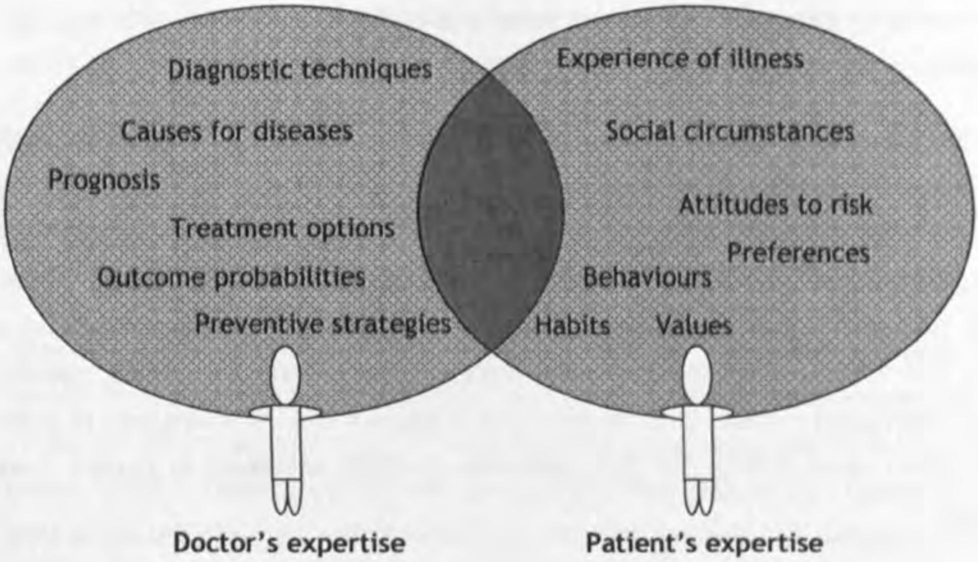


Figure 3.2: Expertise brought into the consultation by doctor and patient

Engle, challenged the view then held by most of the theoretical frameworks associated with traditional reductionist biomedical models. The RCGP model emphasised the need for moving forward from the traditional consultation focus on the diagnostic and therapeutic objectives to comprehensive analysis of a patient's problem. The disease illness model presented by Stewert and McWhinney (1985), and subsequent publication with their colleagues (Stewart et al., 2003) provided much stronger emphasis on these two agendas.

In the doctor-centred consultation style, a doctor may possibly put more emphasis on organising the consultation activities, managing the time and resources Stewart et al,, 2007). They may also assure that no harm is done to the composure or self-control that is needed to support the rest of the consultations of the day; as a result the consultation sessions may become more punctual. A doctor may also try to encourage the patient to present more objective information regarding the problem and more closed questions would be used. Therefore, this style is also referred to as being 'disease centred'.

Patient-centredness often encourages the patient to take control of the decision making process, to share the power traditionally vested on the clinician and facilitate explorations within both the disease and illness perspectives (Baker, 2005). The other important aspect of this approach is the introduction of consultation 'components' rather than 'tasks', where the latter could imply an inflexible structure hindering the patients (Stewart et al., 2007).

While the doctor-centred styles come across as efficient, they may fail to explore the patients' true concerns and expectations or to address the problems that are affecting their health. A doctor's ability to facilitate shared decision making and meet patients' preferences are also influenced by general consultation skills, and the majority of consultations still remain to be doctor led (Ford et al., 2006).

Patients prefer patient-centred approaches; good communication, partnership and health promotion (Little et al., 2001). Developing an effective patient-centred consulting style is now an established part of GP education.

3.2.5 Time and contextual elements

Stott and Davis (1979) discussed the need for having a practical potential for any general practice consultation. They presented their framework with four components to act as an 'aide-memoire'; as a practical model "easy to memorise, understand and use". This widens the consultation process from focusing only on the main presenting problem to include its continuity of care and exploring opportunities for health promotion. They acknowledged the availability of time as a challenging factor. Though this model was presented in 1979, when primary care computerisation attempts were still in its piloting stages, Stott and Davis also discuss the potential in computer systems for supporting continuity of care aspects by prompting the clinician.

Considering the number of patients a general practitioner has to consult within a surgery session, the importance of maintaining unvarying efficiency and acknowledging the secondary tasks associated with the consultation process have been recognised. Byrne and Long introduced time and resources management as separate tasks. This aspect is discernible in many consultation models that appeared afterwards. Pendleton also discussed the importance of time management. This became further instituted as 'housekeeping' in Neighbour's model; covering the tasks related to termination of the current consultation and for the preparation of the next consultation.

3.2.6 The medical record

The role of the medical record has not been widely examined in the theoretical frameworks. Stott and Davis mentioned the importance of the medical record to provide knowledge about patient, family and environment. They linked the role of a 'good medical record' to continuity of care.

3.3 Observing the consultations

3.3.1 Objectives for consultation analysis

The observation and analysis of the consultation interaction can be classified as a 'workplace study' approach (Jordan and Henderson., 1995); the observation focuses on the doctor's interactions with the other individuals (i.e. patients) or physical objects in their work environment (the consultation room). It acknowledges that the ordinary actions of the individuals and their interactions with the social and material world are influenced by the "social and material ecologies". In other words, the knowledge utilised and the observable actions need to be studied together with their contextual environment.

The early studies using consultation observation techniques mainly aimed at identifying its content. They resulted in generating descriptions about the consultation process and creation of theoretical models. The progressive changes of the consultation theories, exploration of the patient's participation and acknowledging the psychosocial context patient brings into the consultation have a closer association with the subsequent developments of the observation techniques. For example the Byrne and Long's consultation model presented a sequence of observable consultation tasks based on audio recorded consultations. Glyn Elwyn (2005) considers these early discoveries based on consultation observations as providing evidences for the 'paternalism' expected within the doctor dominated consultations.

Then, as discussed earlier in this chapter Engel's recognition of the biopsychosocial elements, McWhinney et al's representation of the illness perspective and Pendletons' acknowledgment of the 'other problems' of the patients etc emphasised the need for considering the patient's participation to the consultation. As a result of those developments patient's involvement in the encounter acquired an importance similar to that of the doctor's. This includes the patient's contributions via non-verbal means of communication and the doctor's attempts to encourage them. In parallel the observation motives changed; observing this wider participation required the recording techniques be more comprehensive.

Similar to Elwyn's notion of 'Descriptive' and 'Prescriptive', Rudebeck (1993) presents a categorisation around the concept of 'explorative' and 'normative' approaches to asses the content of the consultation. Explorative consultation studies are aimed at discovering its content whereas the normative studies attempt to define the ideal content of the consultations. The following sections present the observational approaches and techniques used by number of research studies and their underlying technical and analysis frameworks.

3.3.2 Stages of consultation analysis research

Malterud (1995) discussed the need for the adoption of a methodological approach to covert the observations into knowledge. He presented four steps for performing discourse analysis in consultations;

1. Registration – observing consultation
2. Transcription – transforming the observation to data/written text
3. Coding – classifying the data based on their meaning
4. Interpretation- interpreting the meanings in relation to theoretical frameworks

The transcription and coding or the phase of transferring the observations into analysable data compatible with available assessment frameworks defines their research potential.

Bailey(2008) describes three fundamental characteristics that define this phase of a consultation analysis research;

1. Judging the level of detail required or the reduction,
2. Data interpretation
3. Data representation

He further states that the decisions related to each of the above characteristics are influenced by the research objectives and the methodological assumptions.

Those data compilation stages are then followed by the phases where the meanings behind the interactions are explored and interpreted. For an accurate interpretation of the interaction meanings underlining an observation the presence of the visual elements are essential. This could include not only the non-verbal communicative elements, but also the material elements such as the room layout and the use of equipments. Even though techniques exist to add non-verbal features to a transcription, for example indicating the duration of a pause, describing the gesture etc, they are not capable of projecting a complete description, time consuming and their interpretation would be subjective.

3.3.4 Consultation observation approaches and techniques

The observation stage gathers data on the interactions and other applicable attributes into a dataset for processing, interpretation and analysis. There are widely used two approaches (Weingarten et al., 2001);

1. **Direct observation** – direct surveillance by scrutinizing the observable interactions
2. **Indirect observation** - assessing the performance using surrogate data sources.

Rethens et al (1996) presented a breakdown of describing these direct and indirect observation approaches. They further specified the characteristics distinguished by those approaches and their implications for assessment of the consultation process (table 3.2).

	Assessment of doctor's performance (behaviour in daily practice)	**Assessment of doctor's competence (capable of doing)**
Direct observation methods	▪Audio/Video recording in practice ▪Introducing a human observer ▪Use of standardized patients in practice	▪ Oral examinations with patient ▪ Audio/video recording of a test situation ▪ Observing a test situation with patient ▪ Standardised patient in a test situation
Indirect observation methods	▪Clinical notes review ▪Review of prescriptions, referral letters ▪Data from other related services e.g. pharmacies, hospitals ▪Critical incident review ▪Use of trained surveyors ▪Activity analysis	▪ Written examinations ▪ Interviews ▪ Use of vignettes ▪ Oral examinations without patients ▪ Surveys

Table 3.2: Categorisation of available methods for quality assessment of general practitioners (Rethens et al., 1996)

The direct observation techniques offers the greatest potential to asses what actually takes place in the consultation. It holds more validity; it enables unswerving capturing of interactions, allows the subject of the observation to remain in the usual practicing environment and places less demands on the doctor to adopt. This method of observation is sometimes referred 'habitual videotaping' (Vleuten, 1996). However, if the technique used for this approach introduces an external observer element (human/equipment), a possibility exists for it to interfere or modify the content being studied. Covert direct observation has the greatest potential in capturing 'real life' consultation encounter (Rethans et al., 1991). However the significant ethical implications make it impractical.

Malterud (1995) advocates the use of video recording as the most suitable technique for discourse analysis of consultations. He compared three possible alternatives;

1. Having an observer to sit in,
2. Viewing using one way screen
3. Video recording.

While having an observer sitting in the consultation provides direct access to the event, and captures more details about the interaction context it has its disadvantages of influencing the interaction under observation, being subjective and only capturing a momentary picture of the encounter. The one way screen approach is not easy to deploy. He concludes the video recording to have the least effect on the interactions and capable of providing an unbiased recording of the event.

Simulated consultations/standardised patients have also been widely used (Rethans et al., 1991). It is acknowledged that the patient characteristics together with their presenting problems and the medical history influence the consultation process. The use of actors with pre-briefings and computer systems with pre-loaded medical histories permit controlling some of those factors that could introduce variations to the consultation process. This approach also needs more preparations, resource allocation and may not be practical to integrate into normal workflow. However, particularly the ability to control patient characteristics is useful in investigating the aspects of doctor's performance and management of care to be evaluated. Video recording of consultations with standard patients are frequently used for validation of consultation assessment instruments. Some other approaches of using simulated patients have even included introducing them to a normal practice session without the knowledge of the doctor.

Written test or clinical examination based assessment techniques may not reflect the actual real-life performance of a practitioner. Indirect assessments based on analysing doctor maintained clinical documents and completeness of medical records have raised reliability considerations (Norman et al., 1985). On the whole the selection of the observation approach remains one of the significant methodological decisions in consultation observation research. It has been proven by number of studies that the amount of detail needed to support the analysis objectives and the aspects of observation decide the type of the recording approach to use (Heath, 1998).

3.3.5 Direct observation of consultations

3.3.5.1 Audio recording based direct observations

Audio recording based direct observation techniques primarily focus on capturing only the verbal interactions. The transcriptions of the conversations are the data output. Byrne and Long's (1976) theoretical model for consultation was based on approximately 2500 audio recorded primary care consultations from UK and New Zealand. They analysed the transcripts of the doctor-patient conversations prepared from those audio tracks. These observations also recorded certain characteristics of the speech such as the incidents of mumbling and utterances with monosyllables.

Rudebek (1993) explored how the use of audio recording based assessment methods has contributed to the developments of the conversation analysis facet of the consultation research. His review indicates that the use of audio recording based strategies have resulted in giving prominence to the communication skills, which subsequently used interchangeably with consultation skills. Maguire et al (1978) justified the effectiveness of audio recording based methods with no significant differences detected between the two observation methods. However they acknowledged the additional value offered by the video based methods.

The transcription stage based on the audio recording attempts to capture the paralinguistic elements of the verbal interactions; speed, emphasis, volume, interruptions, overlapping, repetitions, pauses and so on. Malterud (1995) discusses the importance of those properties in presenting the "*competition of social control between the participants*".

An utterance is considered as the smallest classifiable segment in a verbal interaction. The utterance-by-utterance coding is recognised as a systematic approach for converting verbal interactions to an analysable form. This could be a full sentence or an incomplete part of a sentence. Depending on the basis for analysis number of qualities have been defined by researchers, following are commonly used in interaction analysis in consultations;

1. Form - the grammatical mode of the utterances; statement, questions, or a response to a question.
2. Function – the purpose; clarification, information gathering, informing etc
3. Content – the contextual information; diagnosis, examination, social etc
4. Structure – interaction features; kindness, dominance, blocking etc

001 D: so it was ye: you who came back again ....
002 .... as for what we talked about what has happened?
003 P: just
004 now I do not feel anything
005 D: no
006 P: but I did have a period of
007 about a week and a half after I had been here last time that was
008 ....(mumbling 1,5 sec) when I had quite a lot of headache
009 D: hm hm
010 P: (mumbling 7.3 tec)
011 it worked ....reasonably well
012 anyhow
013 D: hm hm
014 P: but I was dependent on taking tablets
015 D: I understand
016 P: and: there were a few nights I slept very lit lie
017 D: yes ....did it disappear completely?
018 P: now I haven't
019 noticed anything. I had a tiny touch on Wednesday
020 two days ago ....
021 D: hmhm
022 P: (mumbling ....
023 ....8.2sec)
:

Box 3.2: An extract from a consultation transcript (Nessa and Malterud, 1990)

Figure 3.3: Dictaphone with external microphone (left) and transcription machine with foot paddle controller (right)

The hardware profile of the audio recording based techniques primarily involved a use of a studio recording device. This could be a portable sound recorder with internal microphone such as a dictation machine placed on the doctor's desk, an external unidirectional or multi-directional microphone attached to a sound recorder.

The transcription involves transcribers listening to these recordings and converting the conversations into written text. There are software applications that could automatically generate transcriptions based on audio recordings. However the variations of the patients' voices, the movement of the subjects, background noises and the dissimilar consultation room layouts mean this approach is not often feasible.

3.3.5.2 Video recording based direct observations

Video observation has two principal advantages over other observational techniques. Firstly the amount of information captured is significantly detailed and comprehensive (Vassilas and Ho.,2000). Secondly, the captured data can be retained with no loss of its richness for reviewing; a feature termed as the permanence (Grimshaw, 1982). The review of the interactions could also be based on number of sequential analytical levels.

David Pendleton (1984), led the way in using video recording of consultation to propose a new model for consultation with seven tasks. He gave prominence to a holistic view about the consultation while promoting concepts such as shared decision making and positive understanding based on a detailed analysis of video recorded general practice consultations. Considering the revealing nature of the video recording approach, Pendleton prescribed a set of guidelines to follow before, during and after recording. Commonly referred as 'Pendleton rules', these are primarily aimed at assuring the patient privacy and supporting performance assessment aspects.

Video recording enables exploring of the ways of people interact with each other and with the objects in their environment in order to accomplish their tasks. This includes the reflexivity aspects of social interactions. Heath and Hindmarsh (2002) presented that the need for having video based observations approaches to analyse the details of consultations in its "naturally occurring" environment. Video recording enables the researchers to analyse emerging characteristics during interactions, to observe them in their usual ecologies which is referred as 'situated actions'. They proposed that when analysing the face to face interaction, the admitting of the impact of the "bodily conduct and the material environment" is paramount.

Another fundamental standpoint they offered is the concept of how the interactions progress within a specific encounter. This refers to the ever-updating nature of the interactions; where the participants learn from each action, improves their orientation about the impact of the material objects or the style of communication and progressively develop the conduct. This is referred as "architectural inter-subjectivity" or the "context sensitivity-context renewing" nature of interactions. On other words this is the sequential relevance of the interactions.

Based on the literature review using studies published from 1966 to 2000 to assess the validity of video recording techniques, Coleman (2000) identified seven different objectives (box 3.3).

1. To assess the reliability of methods for studying the consultations
2. To analyse the doctor-patient interactions quantitatively
3. To identify how doctors behave when consulting patients with psychological or psychosocial problems
4. To perform inter-observer reliability testing for researchers doing direct observations
5. To assess the accuracy of medical record keeping
6. To perform qualitative analysis of patient's and doctor's view
7. To assess the impact of new technology on doctor-patient interactions

Box 3.3: Applications of consultation video recording methods for research (Coleman, 2000)

3.3.6 Technical profiles of video recording based methods

Employment of video recording methods involves the use of audio visual recording equipments. These could take the form of one or multiple video cameras. They could have internal microphones or externally located microphones for capturing verbal interactions separately. The angle and the view of coverage are crucial. There are noticeable developments in the technical profiles of the recording linked both with the changes of the insight into the consultation process and the progression of the technology.

The video recordings done as part of the GP assessments have been predominantly using single cameras covering both the doctor and patients. Pendleton (1984) and Campbell et al (1995) used a single camera setup for their consultation process analysis studies. The study by Kaner et al (2007) considered 29 consultations video recorded using a single digital video camera covering the patients and doctors upper bodies and doctor's use of a decision support tool.

The association with the participants and the objects in their encounter environment together with their sequential nature have influenced the Heath and Hindmarsh (2002) in selecting the video recording angles and subsequent data analysis. They positioned the cameras to capture the faces and their bodies as much as possible and also including the objects relevant to the consultation (figure 3.4). In order to accommodate a reasonable level of movements for the participants a wide angle view with additional marginal space was used.

Pearce *et al*, (2006) video recorded 128 consultations with 20 GPs using a single digital video camera. The single camera captured a video angle view of the consultation room. Doctor operated the camera using a remote controller. Their research method utilised a flexible technical profile based on the layout of the room, arrangement of the consultation area and the level of background noise. This includes a combination of digital or analog cameras with mono or multi directional external microphones. The video processing was done using separate processing unit. Box 3.4 presents their technical profile.

Ram *et al*, (1999) used two cameras with built in microphones. The two cameras covered the consultation room and the examination room. The doctor was responsible for switching the cameras based on the location of the activity. The doctors in that study also recorded the data about the encounters into a logbook. This included the details of the patient's gender, age, presenting complaints and duration of the consultation.

Figure 3.4: The camera angle suggested by Heath and Hindmarsh (2002) to capture the encounter between the doctor and the patient in the general practice.

Digital and analogue digital cameras used – tape as storage medium
    Digital camera: Sony TRV900E Analogue camera: Sony Hi8 TRV65E
Seperate machine for analysis – Sony EVC 500
Normally multi-directional PZM microphones used
Mono-directional microphone Sennheiser MKE300 used when background noise present

Box 3.4: Hardware profile of the Health and Hindmarsh's (2002) fieldwork

A study for analysing paediatric consultations in primary care (Cahill and Papageorgiou, 2007) used one or two video cameras, based on the coverage. Cameras were aimed at capturing the potential triadic interactions between the doctor, child patient and the accompanying adult.

Theodam *et al*,(2003) successfully piloted a three channel recording setup for primary care consultations. The power of a multi-channel approach to obtain a comprehensive view of the consultation including the non-verbal interactions with the patient and the use of the computer was recognised by a study comparing it with the single camera approach (Leong *et al.*,2006).

Figure 3.5: Video recording hardware; Analog (top left) and digital (top right) cameras using tapes as storage medium, a multidirectional desktop microphone (bottom left) and a mono-directional microphone mounted on a camera

The cost and complexity of multi-camera setup has hindered its widespread adoption. The use of low cost digital video cameras has reduced the capital cost for the recording equipments. The output is comparable to recordings with professional cameras with no compromise in their research value. The digital recording media provides facilities for synchronising multiple files, ease of analysis based on the timelines, more aspects of the recording to be processed, smaller physical storage mediums and better quality but requires computers for processing and requires dealing with files of large sizes.

3.3.7 Differences between audio and video recording methods

Use of audio recording techniques present the researchers with less technical challenges, they are cheaper to put together, easier to deploy, more portable and can be resourced easily. For analysis focused on verbal interactions, audio based outputs offer data with less distortion. However, the audio recording techniques can not capture the non-verbal interactions amongst the doctor and the patient, difficult to analyse situations when both participants are talking at the same time, if patient is accompanied by another person, having young children as patients, doctor interactions with other objects in the environment including the use of medical record and physical examination activities. Situations where either of the parties has left the room within the consultation or the impact of the interruptions are also difficult to asses only based on a sound track.

Videos can capture the nonverbal interactions. The ability to revisit the captured material as many times as needed is a positive feature. However, there are concerns about 'performance' rather than 'behaving'. Some even argued videotaping as a means of recording a performance (McKinley *et al.*,2001).

3.3.8 Subjectivism and other challenges

Subjective nature of the consultation assessment strategies has been a considerable challenge confronted by that most research methods looking into its content and circumstances. A concern raised by Rudebeck (1993) about the prospect of the video recorded approaches is that despite its information richness and completeness, using it as an observation technique might distance the observer from the reality. He states this by saying "*there is no rewind button in our surgeries*".

Rudebeck also discussed the danger of applying non medical interaction research approaches to study the consultation content. Nessa and Malterud (1990) describe how the observer specific viewpoint of the interaction decides the consultation content. Regardless of the doctor and the patient having their own intentions for interactions, only those detected by the observer and their judgments about those are represented in the research outcomes (figure 3.6).

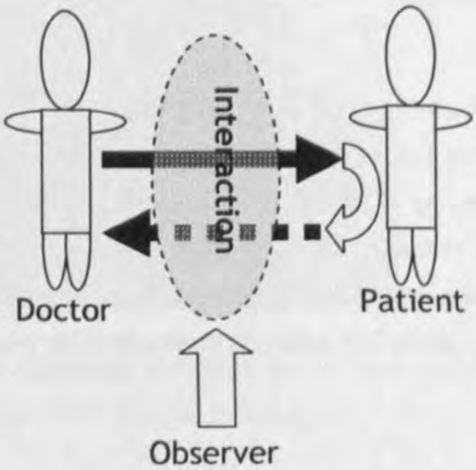


Figure 3.6: The observer's perspective about the interaction

Reliability of the assessment technique may also be challenged by the variety of consultation objectives or not having control over the case selection. Problems of grouping could occur when video recorded consultations from daily practice are compared. This is mainly linked to the fact that each doctor in the research sample could be meeting different patients with dissimilar illness characteristics. The time required to make a reliable judgment have been recognised as problems even in studies with standardised patients (Newble and Swanson, 1988).

3.3.8.1 Techniques for introducing objectivism

There have been experiments for improving the observation techniques to capture aspects that could be detectable using objective techniques. Considering the aspects of interactions within a consultation encounter and available techniques both verbal and non-verbal interactions could be subjected to such assessment approaches.

It is feasible to identify the level, start and end of voice, occurrence of silence and their sources based on software and hardware based approaches used in usability engineering fields. Regarding the non-verbal interactions aspects, the movements of the doctor and patients, their gesture related information and direction of gaze could be measured. The computer mediated consultations provide additional avenues for exploring the interactions with the computer by means of monitoring the states changes of its human computer interaction interfaces.

Human computer interaction development research targeting disabled users employ gaze controlled applications. There are toolkits that can reliably measure the area of screen focus and its movements unobtrusively by sensing the changes of eye orientation (Carlos *et al.*, 2005). No reported studies using such methods as a direct observation approach in clinical consultations were found. However a similar technique has been deployed for a medical education experiment using virtual patients (Stevans *et al.*,2006), where two webcams linked to a software track the medical students head and hand movements.

Although not utilised for consultation observation, Oliver *et al* (2006) proposed an activity monitoring system based on multiple real-time data streams representing user's interactions with the computer system. The system consists of two mini microphones, small size firewire camera and sensors linked to the keyboard and mouse. Using a framework with layered approach for sensing, inferring and encoding data generated by heterogeneous data sources this system provides interpretable data useful for interaction analysis.

3.3.9 Consenting and recruitments

The consenting process has a significant bearing in the recruitment of patients for direct observation studies during normal consultation session. There are concerns expressed about the vulnerability of the patient's compulsion to attend for such studies due to the involvement of their usual consulting doctor. Servant *et al* (1986) argued that higher consent rates are present only in studies using coercive methods of recruitment. There study showed that only 10% of their patient sample agreeing to be filmed. However the method they used required the patients to volunteer for the filming rather than inviting them to participate and allowing them to make an informed decision.

Themessl-Huber *et al*(2008) reported non-participation rates ranging from 3% to 83% based on 16 audio recording based studies. Analysis of 44 video recording studies discovered this to be ranging from 0% to 83%. The average non-participation for direct observation using audio or video methods is 16%. This review also indicated the tendency for participation increasing with the patients' age. Face-to-face recruitment and doing so immediately before the consultation also resulted in higher participation rates. However the impact of the recording or the sense of being under scrutiny to the GP's overall consultation behaviours or their privacy has not been analysed. Younger GPs and those who are familiar with the recording techniques involved in research or know the researchers conducting the particular recording study personally are identified as more likely to involve with consultation recording sessions

Ram and colleague (1999) did their consenting process at the practice's reception, where the receptionist informed the patients about the study and obtained consent. Patients carried a coloured card into the consultation session indicating whether they agreed for filming or not. Cambell et al's study provided instructions and asked the trainee GPs to record their daily consultation sessions. The participant GPs reported no significant difficulties in obtaining patient consent or facing any technical difficulties. Direct recruitment of patients by the GPs or the researchers have proven to be successful than the involvement of the practice staff members (de Lusignan *et al*, 2005).

Current research ethics guidelines pertaining to the consultation recording stipulate the researchers to directly recruit the patient after providing them with detailed information and for the patients to explicitly give their consent. While this provides increased reassurance for the patient and protection for the research, this could introduce a sample bias and limit the generalisability of the findings.

In 1994, the GMC issued a set of guidelines related to the use of video recording techniques in consultations (box 3.5). Their objectives were mainly to limit any possibilities for recorded data misuse. The decisions for asking patient consent after the recording has taken place is justified by the fact that some studies show patients regretting about having being observed. Some recommended allowing the patients to withdraw even a week after the recording session

- Having a valid ethics approval for the research project
- Before the consultation patient should be informed about the following;
  - The objectives of the project, who will witness the recordings
  - Withholding the permission or withdrawing does not affect the quality of care
  - Implications of giving the written permission, right to review the explanatory materials
- After the consultations the researcher should ensure that;
  - The patient is informed about theirs right to withdraw the consent
  - That the recording will not be used for any other purposes than the original research
  - Patient can view the recording if they require
  - The protection to the recording is similar to that given to a medical record
  - If patient withdraw the consent the recording is erased immediately

Box 3.5: Summary of GMC guidelines on visual and audio recording of consultation for research purposes

3.3.10 Impact of the observation process on the consultation

There is a possibility that the presence of the recording equipments in their normal consultation room makes patients uncomfortable and leads them to feel unnatural. Bain *et al* (1993) considered this as an unacceptable intrusion. However, there could be a difference between the patients who have never taken part in such a consultation with those who have; the latter could be the case in most of the teaching practices. Coleman (2000) emphasises the need for justifying the data collection technique compared to the research question.

Usually the influence of the observation on the consultation process is assessed by post consultation interviews or questionnaires. A study (Cambell *et al.*,1995)comparing the questionnaire results of a group of patients who participate to a video recorded consultation session with another group who had consultation without video recording found no difference in patient satisfaction. Ram *et al* (1999) also found the video recording in daily practices as valid, reliable, accepted by both doctor and patients and as having acceptable levels of associated costs. They reported that 71% of the doctors who participated reported as having no influence by the presence of the video cameras except in the first encounter of the recording session.

Having external recording equipments or observers could have a consequence on the doctors' usual behaviour; term coined as 'audience effect' (Cronk et al.,2009) or 'reactive effect' (Redman *et al.*,1989). However, number of studies suggests that the impact of the presence of video recording equipments on the doctor's behaviour is inconsequential. Pringle and colleagues (1990) presented a similar conclusion after analysing the behaviours of four doctors who took part in a study with 300 recorded consultations. They found no difference in the behaviour regardless of the doctors being aware of the filming or not. The recording equipments used by the research studies have also become less obstructive with the technological improvements.

3.3.11 Observing the use of computer during the consultation

With the progressive computerisation of UK general practice the objectives of the consultation observation research broadened to include technological aspects. This includes researches aiming to assess the role and the impact of the computer within the consultation, investigating the ways for the clinicians to acquire the essential skill set to integrate the new technology and discovering the patients' view about computer mediated consultations.

One of the early studies (Brownbridge *et al.*, 1985) using a video based approach aimed at assessing the impact of computer on the delivery of care in fact happened in the early stages of UK general practice computerisation. This was in 1985 during the period when the 'Micros for GPs' scheme was. The GP system used for this research was developed by the IBM, collaborating with the Sheffield University (Abosolon *et al.*,1983)). This system known as the 'IBM-Sheffield', used a terminal with a VDU. They used 730 video recorded consultations and matched thirty consultations supported by computers with another set of consultations with comparable consultation characteristics but without the use of computers, to perform the comparative assessment. Rating was done by six experts. The rating scale recorded consultation events identified under seven areas, and each event rated based on a seven point scale (box 3.6);

1. Identifying the complaint
2. identifying the background factors
3. conducting the physical examination
4. interpreting the findings
5. outcomes decisions – prescription, referral, recall, plan
6. communicating with patient
7. Making an encounter record

Box 3.6: The seven consultation task areas under which the doctor's performances were measured by Brownbridge et al (1985).

Greatbatch et al (1995) video recorded the consultations of a single practice before and after the introduction of a computer system, to discover the impact of the computer. The computer system was VAMP, the most widely used GP system at that time. The role of the computer was largely limited to the drugs prescription stage; the paper record was still used for other tasks, for informational gathering and updating the patient's medical record. Despite the limited amount of facilities offered by the VAMP system compared to those that appeared in late 1990s, the insight offered by this research about how the 'visible and audible' operation of the computer system interferes with the doctor-patient interaction is fascinating. It recognised the background use of computer, the attention needed to fill in certain prescription related input fields, to respond to prompts, the limitation of having the computer screen in a fixed position, 'collaborative reading' and so on.

Pringle et al video recorded 50 consecutive consultations each from four GPs to identify the topics covered by the doctor and the patient and to compare those with the data entered into the medical records. They reviewed both the manual and computer entries. After comparing the diagnoses, prescriptions and referrals they found that more amounts of topics were entered in to the manual records but in terms of the diagnosis, more were recorded in the computerised medical record.

Not only the occasions of computer use but also their durations, how the computer is used, and the position of the computer hardware could decide the level of impact the computer use have on the patient-centeredness. For example, the positioning of the computer screen in a manner that enables the patient to view it could encourage their participation to the consultation and for the decision making process.

Gibson et al (2005) used a combination of conversation and video analysis techniques to investigate the doctor's use of computer while interacting with the patient. This study aimed at analysing the doctor's use of decision support systems used 22 video recordings. These were simulated consultations due to the disease specific nature of the analysis. Two cameras were used; one focusing on the computer screen covering the computer screen, key board and mouse and the second with a wide angled view of the doctor, patient and the computer. Researcher uses this second camera also to note the details about participants' direction of gaze, gesture and posture. The two video channels were synchronised and merged into a single screen and used for the transcription. The transcribed actions covered seven observable interaction aspects;

1. Verbal interaction
2. Doctor's active use of computer
3. Doctor referring to the paper record
4. Doctor looking at the patient
5. Doctor's body movement
6. Patient looking at the doctor or the computer
7. Patient's body movement

Als (1997) looked into the aspects integrating the computer to the consultation using 39 video recorded consultations with five different GP. He used the recordings further to facilitate 'simulated recalls' both with patients and the doctor. This contributed immensely to recognise and for understanding the use of the computer as an instrument to manoeuvre the consultation process. For example they discovered the patterns of computer use which indicated that doctors using it to introduce a 'time-out' or to add authoritative attributes to their decisions and so on.

The role of the computer has been conceded gradually and the traditional dyadic view about the consultation is in fact now recognised as a triadic one (Scott and Purves,1996); interactions involving doctor, patient and the computer. Pearce *et al*(2006) looked into the doctor's interaction with the computer within the consultation and their relationships with the doctor-patient interactions. They considered both verbal and non-verbal interactions, identifying the interactions related to information gathering, information giving and printing. The doctor's and patient's gaze were also analysed. The underlying theoretical framework of his study considered the doctor and patient as 'actors' and the computer as an 'actant'. The analysis was focused on recognising how each of them 'perform' based on the available information and the flow of the interactions.

Figure 3.7: A consultation video with wide angle view of doctor, computer and patient

Using the video recordings of 141 consultations they found two categories of behaviours related to the physician's body movements. The type named as 'unipolar' users maintained their lower body directed towards the computer most of the time. The 'bipolar' users frequently changed the orientation of the lower body between the computer and the patient. Patients also demonstrated a similar alteration between the doctor and the computer; creating two distinct conditions as dyadic and triadic. They expanded this further into a topology covering variations of observable interaction styles described as 'keys' and behaviours attributed to all players (table 3.3).

Actor/ actant	Keys (interaction styles)	Behaviours
Physicians	**Orientation of the lower body**	Engaging – giving attention to the patient
	Unipolar –Focus towards computer	Disengaging – shifting attention away from patient.
	Bipolar-Focus alternating between computer and patient	Cogitating –giving attention neither to patient nor to computer
Patients	**Orientation of body and conversation**	Screen controlling – content of the screen referred during consultation
	Dyadic-interacting with doctor, computer as a tool	Screen watching – focusing on the screen
	Triadic-both doctor and computer equal partners	Screen ignoring – disregarding the screen
Computer	**Type of influence**	Informational – providing useful information
	Active-demanding doctors attention	Prompting – reminding tasks
	Passive-on demand supply of information	Distracting – interrupting the doctor-patient interactions

Table 3.3: Interaction styles and behaviours observed in doctor-patient and computer by Pearce et al(2006)

In a separate study Gibson and colleagues (2005) analysed the doctors' use of computer, in particular the use of the different areas of the screen with the intentions behind them. They presented those observations in their transcriptions (presented in next section) which enabled the discovering of other incidents related to the computer use. One such observation is the phenomenon of 'verbal prescription'. They noted that when the doctors want to make a change to a prescribed drug, they disengaged from the computer, turn towards the patient and make their intentions know and the patient reciprocates giving attention to the doctor. Subsequently when the doctor is printing off the prescription, both participants usually look at the screen in silence.

They also noted incidents of doctor pointing a certain areas of the screen inviting the patient to read certain details on the screen, particularly related to the information provided by the decision support system. They conclude that the consultation consists of series of coordinated activities in both verbal and non-verbal form and doctor's multi task during the consultation while incorporating the technology. The following two statements in their concluding remarks have a noteworthy association with the objectives of the study presented in this thesis.

Video recording has also been utilised for conducting cognitive based approaches to explore the achievements of the doctors' interactions with clinical system interfaces. Instruments used in the usability engineering and cognitive science fields have been regularly adopted for determine the influence of clinical systems on the consultation interactions. James et al (2001) employed a portable usability kit to collect data about clinicians' interactions with a decision support system. A video converted captured the clinician's interaction with the computer interface into a video cassette recorder and microphone recorded the verbal interactions and the sound of keyboard use. The rest of the recording equipments mounted on trolley with a monitor allowed a technician to view and control the recording away from the encounter area. A unique feature of this system is the use of specialised software to zoom and pan specific areas of the screen capture.

> "It (the transcription methodology proposed by Gibson et al) facilitates the understanding of complex activities and thus facilitate needs assessment, design, implementation, change management and benefits realisation of various new technologies"
> "This is a new methodology which could be of use to other contexts of system design and use where three main actors are involved, such as a professional, a patient/consumer and a piece of technology"

Box 3.7: The implications of exploring the interactions between the doctor, patient and the computer as noted by Gibson et al

This three-channel video study signified a number of applications of the consultation observations, particularly integrating the role of the technology';

(1) Assessing the doctor's ability to integrate the information obtained from the patient, computer record and own knowledge,

(2) Comparative assessment of the clinical computer systems based on their ability to support the consultation in an efficient ways,

(3) Methods of training doctors to integrate technology while maintaining a patient-centred focus,

(4) The value of analysing the use of medical record considering it as the entity that would eventually become the recorded abstract of the consultation

(5) Studying the interactions simultaneously so that their meanings are easier to contextualise.

Nonverbal characteristics	Computer use characteristics
• Changes in body posture, body language • Eye contact • Direction of gaze • Use of hands • Computer distracting the doctor • Facial expressions • Cues from patient – blinking, smirking • Doctor missing non-verbal cues from patient • Patient stopping talking when doctor looks at the computer • Doctor talking while typing	• Referring to the information on the computer • Retrieving information • Use of past medical/medication history • Prompts from the computer • Fiddling with the computer without apparent gain • Accuracy of entered data • Coded data entry – correct/incorrect/not coding • Selection of medication and prescribing • Sharing medical record information with patient • Breech of confidentiality due to third part interruptions • Attempts to minimise negative effect • Style of computer use • Disruptions from data recording for quality targets

Box 3.8: List of observable non-verbal interaction and computer use characteristics that are important in a computer mediated consultation (de Lusignan *et al,* 2002).

de Lusignan *et al*(2002) developed a rating scale and proved the possibility of differentiating the impact of two software systems on the consultation tasks. It acknowledged the danger of designing clinical systems merely for supporting the biomedical transactions. Based on series of interviews with a group of experts who took part in the review process, it revealed a list of characteristics related to non-verbal interactions and computer use that defines the course and outcomes of a computer mediated consultations (box 3.8).

3.3.12 Strategies for processing and analysis of observational data

The process of converting the collected observational data into an analysable configuration can be done to different abstract levels and in many forms. They are largely determined by the research objectives and the richness of the dataset. Having an appropriate theoretically based analysis framework supports meaningful interpretation of the collected data.

Consultation analysis approaches are largely associated with the domain of interaction analysis. Those techniques have three process components that construe the data from observations towards the theoretical insight;

1. Identifying the interactions related to the research objectives
2. Categorisation of the identified interactions
3. Comparing and analysing the organised observations

Identifying the constituent sub-events within the consultation is also important. The following sections describe various strategies adopted in the data processing stages and different approaches used for their analysis.

3.3.13 Representing verbal and non verbal interactions

The most commonly used measure to explore the content of the consultation content is the verbal interactions. Representation methods for verbal interactions could vary from the use of traditional orthographies of transcriptions to the use of conversation segments combined with contextual data from other observational media. Coding of the conversation could be done based on an audio recording looking into the purpose of the conversation segment or other aspects such as the tonal qualities. The features captured and techniques used within the transcription phase in fact recognise the suitability of the video recording for this purpose instead of any other methods.

Burgoon's experiment provides significant views about the analysis of verbal interactions in consultations (Burgoon et al.,1989). There the importance of the transcription to support the subsequent phases of coding and interpreting was emphasised. The existence of two components in human communication has been also recognised;

1. 'Content' component – the subject matter,
2. 'Relational' component – additional socioemotional information.

The latter component is dominated by non-verbal interaction elements.

The representation of the non-verbal interactions within the transcripts is not efficient; its time consuming to prepare, might alter the usefulness of the transcript, there are difficulties in timing the both aspects accurately and tend to be more subjective. Cahill et al's (2007) video based paediatric consultation study produced a transcription of the verbal conversations and later the descriptions about the non-verbal interactions were merged into it. An excerpt of a transcribed observation is shown in box 3.9. The non-verbal interactions are shown in italic. This attests the amount of data needed to represent the non-verbal elements in a meaningful way and their function in contextualising the verbal component. This study also analysed the physical location of the participants, and reported about situations where doctor orchestrated the seating of the other participants. Its analysis particularly noted a higher participation when seated in a triangular arrangement compared to a linear.

Heath and Hindsmarsh (2002) used their field work to establish the inseparable nature of the verbal, non-verbal interactions and other artefacts such as material features and objects of the environment. They also proposed the use of multiple cameras as they would provide improved access to coordinated complex tasks. Their research from the ethnography point of view proved the feasibility of combining the video recording, conversation analysis and other indicators related to interactions for obtaining a rich dataset for research. They also pointed out the observable interrelated features of actions and interactions, there positioning with the timeline and how multi faceted observational approach could asses them use a systematic approach.

1. doctor: **ok now I've got you on the computer now** (0.2) **how are you doing** ...? *Doctor smiling, looking at the child, mother looking at doctor.*
2. child: (3.0) hhh e:s
3. doctor: **yer** :::: **so** (.) **um have you come about: your skin again?** *Child smiling at the doctor. Doctor glances back at the computer.*
4. child: (2.0) **yer** = *Doctor looks at child, glances at mother and back to child.*
5. doctor: = **eh** •hhhh° °hhhh

>> lines ommitted

6. doctor: **and how long have you had it like that now?** *Doctor glances at computer, child glances at mother.*

8 child: (1.0) mm ((Laugh)) (.) **for quite a few w[eeks° °]**
9 mother .° ° [**months**] ((*laugh*))

Legend;
(1) hhh = Audible inhalation; **(2) hhh** = Audible exhalation; **(3)** : = Extended sound; **(4) ?** = Rising inflection; **(5) ° °** = Talk is quieter than the surrounding talk; **(6) <>** = Talk is faster than the surrounding talk; **(7)** (=) = Latched utterance, no interval between utterances; **(8) [ ]** = Beginning and end of overlapping talk; **(9) (.)** = A pause of less than 0.2 seconds; **(10) (0.0)** = Silence measured in seconds and tenths of seconds;

Box 3.9: An excerpt from the transcribed data representing the verbal and non-verbal interaction components in a paediatric consultation in primary care

Consultation assessment instruments specifically aimed for measuring non-verbal component of interactions exist. The RCS-O is such a tool (Gallaghera *et al.*,2005) with 34 observable non-verbal interaction aspects organised into six dimensions; (1) immediacy/affection, (2) similarity/depth, (3) receptivity/trust, (4) composure, (5) formality, (6) dominance.

3.3.14 Observational data presentation and preparation for analysis

The methods employed for processing the data collected through the observation techniques should preserve its richness, enhance the research potential and make them fitting for the analysis. This stage of activities usually involved coding, categorisation, linking with other contextual data elements, reducing any unwanted details and presenting them in a format suitable for the inspection.

Byrne and Long's (1976) study initially coded the consultation behaviours under three main categories; (1) Doctor centred (2) Patient centred and (3) Negative. Then they defined four clusters of verbal behaviours focusing on the doctor-patient interactions up to the point in the recording when the diagnosis decision is made. They discovered and defined the interaction categories while they were doing their observations, as opposed to classifying observed interactions into predefined categories. This is evident from the considerably larger number of interaction categories they identified, i.e. 54 doctors' behaviour categories and from the fact that those categories included elements like 'miscellaneous professional noises'.

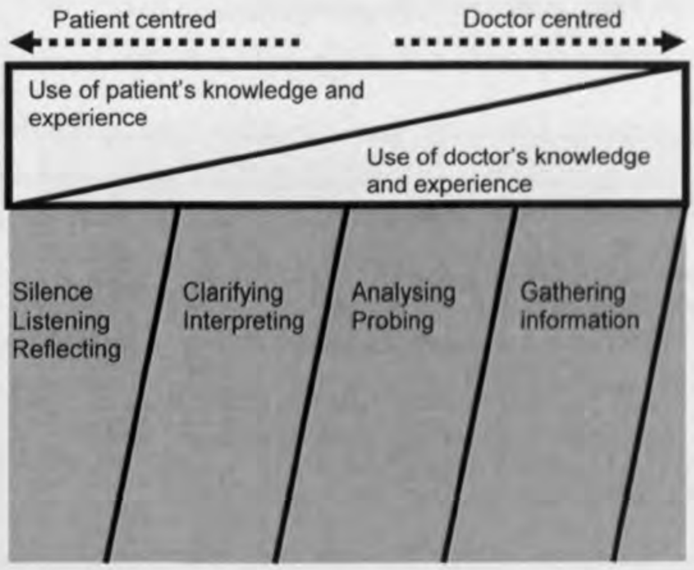


Figure 3.8: The Byrne and Long's adoption of the power shift model to represent the diagnostic behaviours in the consultation.

Analysing consultation video files are much complicated than the audio recordings. It could be time consuming to manually process these data files. Researchers need to utilise additional data processing techniques to convert the interaction information captured within the video filed into knowledge.

Kaner *et al* (2007) also transcribed the conversations of their 29 video recorded consultations. For coding and analysis of the verbal and non-verbal interactions they used the 'Observer' software. This observational software uses an event logging approach, where different aspects of a video are marked, coded and grouped for quantitative or visual analysis. They categorised the non-verbal interactions under three headings and the method of coding was chosen accordingly;

1. Rapid activities – e.g. smiling or head nodding. These were coded continuously

2. Slow behaviours with sudden changes – e.g. gaze – coded discontinuously at 1 minute samples
3. Slow and prolonged behaviour – e.g. posture – discontinuously coded using instantaneous sampling

Their detailed analysis was focused on 10 minute segments of the consultation. This was decided because of the complexity of the data available in the video files. A number of studies have found that this approach of selecting a section of a consultation recording to assess the content of the whole is acceptable . Two other studies have (Henbest and Stewart, 1989; Weingarten *et al.*,2001) found a correlation between the assessments scores based on first two minute samples and the scores given after the reviewing the whole of the consultation. Rather than using a behaviour oriented approaches some other studies adopted a task oriented strategies. There the consultation is considered based on the sequential flow of the consultation tasks and then looking into the interactions that come into sight within those tasks.

Gibson *et al* (2005) used the lines of transcription representing the verbal interactions as a data processing framework. This approach was based on the notion of 'interaction maps' proposed by Heath (1986). He introduced possibility of using abstract representations to record the human interactions in a standardised way enabling the researchers to analyse their verbal and non-verbal components. The non-verbal elements were mostly represented using symbols within the transcription.

- Map as a standardised and simplified representation of human interactions
- Ability to sketch the local geography of all participants, their artefacts
- Locating the precise position of visual and verbal behaviours within the interaction timeline

Box 3.10: Christian Heath's (1986) view of 'mapping' multiple actions of observed interactions

This detailed transcription system allowed the researchers not only to represent a detailed account of interactions but also acts as a permanent, reusable record for re-assessments, further analysis and validations. Later they introduced an additional column to represent the doctor's use of the computer screen with details of the purpose and area of each interaction. Emphasising the capability of this approach to identify and locate the inter-relationships between interaction within the consultation workflow, Gibson and colleagues (2005) presented the phenomenon of 'verbal prescription' which was mentioned earlier.

James et al (2001) created video transcripts based on the screen recording of the clinicians screen. These records contained the screen activity with a time stamp and the transcript of the think aloud actions. Their attempt was to identify successful, failed and suboptimal coding attempts. They recorded the task objectives, response time of the system, user action, outcome and the durations next to the video script (figure 3.9). This data representation mechanism provided an useful interpretation of the clinician's interaction with the system, in a format that allows the usability and cognitive aspect to be explored.

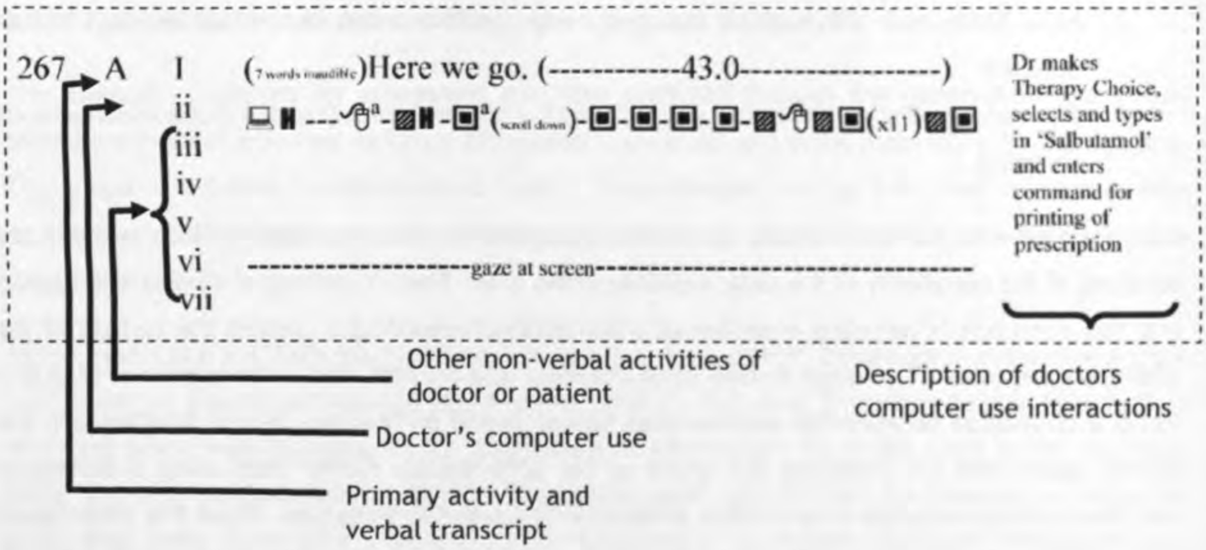


Figure 3.9: Transcription based approach for doctor-patient-computer interaction analysis

Video script	**Activity coding**
00:51:55 Adds a problem, types: manic-depression **User scans list, doesn't select anything** **00:52:08 User tries again** (next time, user finds "Bipolar Affective Disorder, Unspecified")	**Task:** Enter current problem **Said**: nothing **Typed:** manic-depression **Found:** 7 items **RESPONSE TIME:** 0.5 sec **Picked**: nothing **TOTAL TIME FOR EVENT**: 13 sec **Interpretation**: Failure, system did not recognize Synonym
1:15:11 Enters plan, types: dc medformin, start glynase at 2 mg; pt had been having Said: glynase 2mg episodes of hyoglycemia on 2.5 milligrams dose. See me, follow up 1 month RESPONSE TIME: 0.5 sec **01:16:27 to 01:16:28 Adds a medication** "Make that 1.5 mg." **01:16:11 Selects term from list**	**Task:** Modify existing medication **Typed:** glyburide **Found**: 5 items **Picked:** Glyburide 1.5 mg **TOTAL TIME FOR EVENT**: 60 sec **Interpretation**: Successful, system helped user find correct dose

Box 3.11: Excerpt from a video transcript and its associated coding

While the permanent and re-usable nature of the consultation transcripts with annotations indicating non-verbal interactions aspects introduced into them is an attractive feature, researchers still found them difficult to adopt for studies with larger samples and those with broader research objective. There are software programmes that facilitate the management of video files to support analysis. These video data management aspects could be three fold;

1. Organisation of whole video files – video catalogues/libraries
2. Generating smaller video segments from a larger video files and organising them
3. Tagging of segments within the video using markers

Some of those facilities could be built into the video analysis tools. Regardless of the technique or the tools used almost all the consultation research approaches required the assistance of one or more human observers to direct this stage of the processing. Even the more objective assessments based rating scales are not always practical to use with large number of consultations. They were usually designed with an initial stage of objective rating followed by a data analysis phase with the assistance of experts.

Pringle et al's (1986) consultation assessment tool prompts the raters to categorise the consultation tasks every five seconds. The raters have to initially watch the video to get them familiar with its content. This was then followed by four separate viewings to categorise the events under the four interaction categories. It has taken about one hour to observe and rate an average size consultation. The verbal activities were recorded only based on the sound track.

Pearce *et al* (2006) analysed digital copies of 128 videos using the video management software – Gamebreaker. This has facilities for marking video segments, analyse those with related tags in isolation and managing them based on the research needs. Prior to this the videos were viewed by two groups of users; clinicians and sociologists. Tagging was done based on this shared understanding about the insights of the consultation. They considered both verbal and non-verbal interactions. The tagging included the doctor's and patient's gaze. Researchers could then review those tags with their episode durations positioned along the consultation video's timeline (figure 3.10).

Creation of a consultation map based on Pendleton's consultation schedule; frequently referred as 'Pendleton consultation maps', provides a mechanism for graphically representing the degree of involvement of the doctor and the patient to the encounter (figure 3.11). This approach is adopted by a number of researchers to analyse the task content, aspects of patient centeredness, competence and so on (Holmström and Rosenqvist, 2001; Arborelius and Bremberg, 1992) For example, having a consultation map with the mark-up line connecting more numbers of activity markers (i.e. concentrated, higher number of markers) is believed to be representing a more patient oriented consultation as opposed to a map with fewer movements between activities.

Heath and Hindmarsh (1998) started their data analysis by mapping the selected actions on a graph paper. They represented the consultation duration using a horizontal time line and the marked the verbal and other important characteristics on it. A transcript of the verbal interactions was then produced capturing as many speech characteristics as possible. This included the quantified durations for silence and pause of speech measured in tenth of seconds. The second transcript produced a detailed visual map with video frames arranged along the time line with descriptions of events with significance (figure 3.12).

There are specific features expected from the assessment techniques used for consultations analysis; reliability, validity, acceptability, feasibility and educational impact. Reliability concerns of measurement tools often surface in the coding stage and generally mitigated by focused additional training or strengthening the term definitions associated with the coding categories.

1. **Problem identification**
    a. New problem
    b. Continuing problem – present in previous encounter
    c. Doctor initiated health topic – potential problem or patient education
2. **Physical activity**
    a. Administration – reading, writing, telephoning etc
    b. Preparation – before or after activity related to another task like examination, preparing to leave ets
    c. Examination or treatment – mutually for both doctor and patient
    d. Conversational – default if neither does any of the above
3. **Verbal activity**
    a. Medical questioning
    b. Medical information
    c. Social discussion
    d. Instruction
    e. Silence
4. **Secondary task activity**
    a. Patient's concept – descriptions of illness aspects
    b. Educational explanation – attempts to increase patient's understanding
    c. Management/decision sharing

Box 3.12: summary of event coding rules used by the Timer (Pringle *et al.*,1986)

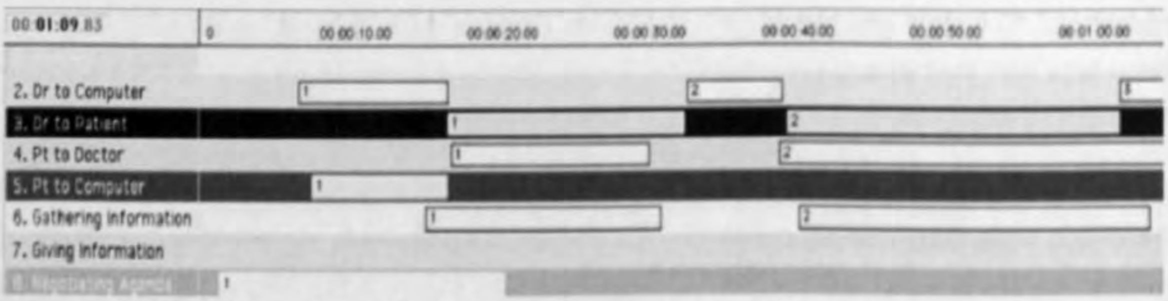


Figure 3.10: The tagged interactions of a consultation video timeline – (Pearce *et al*, 2006)

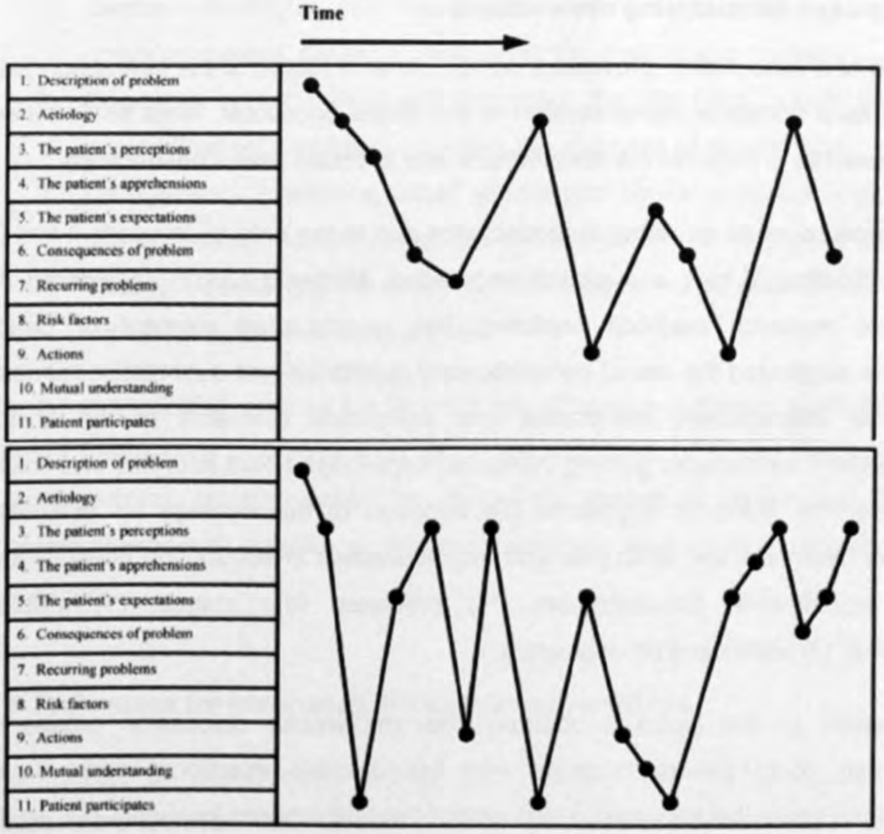


Figure 3.11: Pendleton consultation maps representing a Doctor centred (top) and Patient centred (bottom) consultation

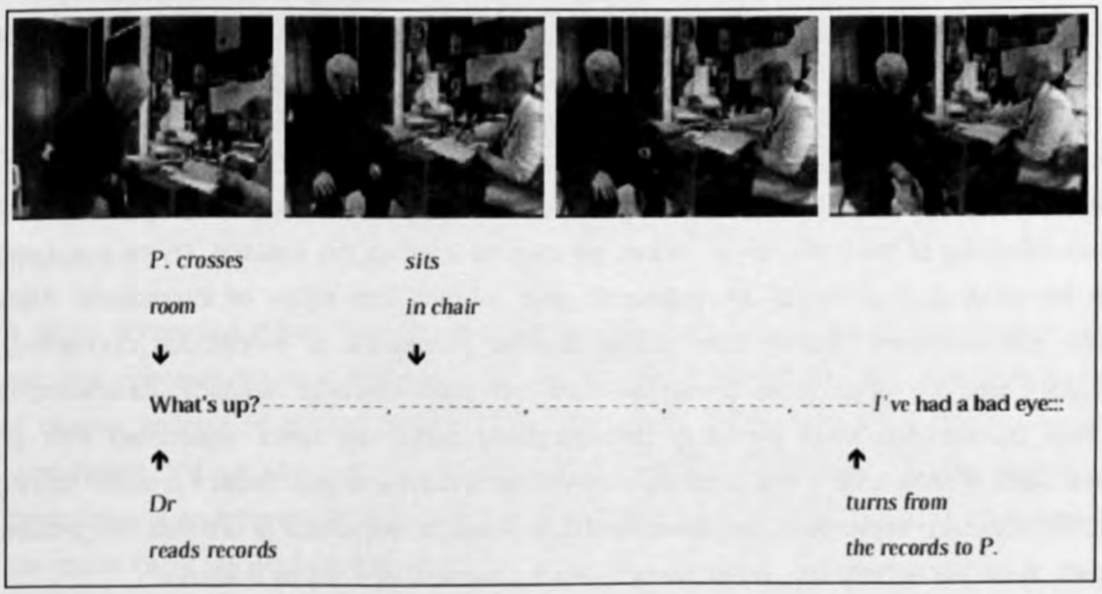


Figure 3.12: Consultation map with video frames, transcribed speech and event descriptions (Heath and Hindmarsh, 1998)

3.4 Theoretical models used for analysing observations

Although a video record of a consultation provides a comprehensive record of the interaction yet it can not be considered as a complete representation of the social encounter. Most studies have utilised theoretical frameworks to interpret the observations and to obtain useful abstractions.

Clinical practice is considered as an art rather than a science due to the unique demands it has for integrating and the application of tacit and explicit knowledge. Malterud (2001) considered the possibility of qualitative research methods capturing this unarticulated element of clinical knowledge. However, he suggested the use of complimentary qualitative and quantitative research strategies to study the 'interactional, interpretive and normative' elements of the clinical consultation. Action research encourages gaining increased knowledge about activities and linking that to improve the practice. Malterud suggested the adoption of this strategy for evaluating medical interventions to overcome the difficulties and impracticalities in conducting consultations under controlled or experimental circumstances. He proposed four stages; (1) problem identification, (2) planning, (3) action and (4) evaluation.

Balint's model was based on the topics discovered from the weekly discussion groups he organised to talk about doctor-patient relations and the doctor's emotional state during consultations. Early consultation theories have used similar evidence bases probably due to the unavailability of established observation approaches and the difficulties in applying rigorous scientific methods considering the unpredictable nature of the differing consultation scenarios that could materialise. Balint in his model presented in 1958 acknowledged the existence of non-biomedical elements such as the 'therapeutic nature of relationships'. However they were not explored in detail by him or in other similar models possibly indicating the difficulty in applying overly scientific approaches to develop consultation theories.

Both Balint's and Pendleton's work indicated the practical nature of consultation studies; that is how understanding of the consultation should be used to improve the practice. Byrne and Long utilised the transcripts of verbal interactions to gain insights into styles of interactions. They observed the variations ranging from doctor directed interviews to empathetic counselling. Consultation studying approaches presented from this point onwards regularly acknowledged descriptive frameworks, often providing chronologically presented tasks associated with an evidence base. Models before this, such as Heron's intervention analysis, Gelat's problem solving and RCGP approach presented consultation functions linked to objectives or ordered into phases. Principally those did not mention distinctive consultation tasks, supported by evidence.

Als (1997) and many other research studies looking into the consultation activities (Booth *et al.*, 2002; Greatbatch *et al.*,1995) have used Grounded Theory as the theoretical basis for their assessment exercises. It is a qualitative research methodology that emphasises the need for generating the theory informed by the data harnessed from the research, whilst the analysis is being conducted. It has four core elements. It recommends the analysis of data iteratively, guided by the information ascertained at each stage. With respect to the consultation assessment research those could be deduced as below;

1. **Codes** – identifying and marking the observed interactions – e.g., doctor looking at the computer/patient, patient looking at doctor, making eye contact
2. **Concepts** – comparing and grouping the identified codes to similar groups – e.g. doctor's/patient's interactions within the episodes of silence time
3. **Categories** – Identifying broad groups with similar concepts – e.g., patterns of computer use, and doctor-patient verbal/non-verbal interactions during the silence time
4. **Theory** – Explaining the observed interactions – e.g., doctors tend to use the computer to initiate an episode of silence time.

Pearce *et al.*, (2006) adopted the Dramaturgical theories of human interactions, which consider that human interactions are based on the accepted rules of social conduct and according to the perceived roles. He considered the doctor and patient as actors, and the computer and other material objects with significance to the consultation as 'actants' to describe how they interact with each other.

3.5 Techniques for measuring the patient-centeredness

The notion of patient-centeredness particularly emphasise the need for observation and assessment techniques to adopt a holistic approach, encompassing all aspects of doctor-patient interactions together with its material environment. Different studies have used various systematic techniques to measure the patient-centeredness.

Henbest and Stewert (1989) devised an approach based on doctors' responses to verbalised offers from patient. The scale used in RIAS , focuses on 'utterances' Roter, 1993). It identifies the objective of each verbal interaction under 34 mutually exclusive categories and measures the frequency under each. The Euro-communication study scale adopted a rating scale focusing on five main aspects of patient-centeredness. Key features of these three techniques are summarised in table 3.4.

A study comparing these three measurement techniques (Mead and Bower,2000) found their resource intensive nature, varying level of reliability, lack of association with outcomes and the use of diverse aspects of patient-centeredness. The complexities involved in the general practice consultation, the variations of needs between the individuals and aspects of continuity of care mean there is an inherent difficulty in recognising an objective, reliable, valid, flexible yet simple to use measure for patient-centeredness

Euro-communication study	
Grouping categories	5 categories
Rating approach	Each rated 0 (poor) to 5 (excellent). Total score devided by maximum possible score, i.e. value between 0 and 1
Patient centred elements	1. Involving the patient in problem-definition
	2. Involving the patient in decision-making regarding management of presented problem/s
	3. Picking up cues from the patient about 'hidden' aspects of the problem or other unresolved concerns.
	4. Exploring issues of patient ambivalence and self-efficacy
	5. The doctor's overall 'responsiveness'
The Roter Interaction Analysis System	
Grouping categories	34 behaviour categories covering both patient and doctor centred talk. Patient centred talk could be grouped into 4 groups.
Rating approach	Ratio of doctor centred to patient centred talk
Patient centred elements	1. Questions and information giving about psychosocial or lifestyle related issues. Counsels.
	2. Patient asking biomedical questions. Request for services or medication
	3. Doctor giving attention – empathy, legitimating, partnership, personal remarks, social conversation, laughs, shows understanding/concern/worry, reassure/encourage/optimism
	4. Doctor attempting to clarify – asking for opinion, checking understanding, request for repetition, ask for understanding.
Henbest and Stewert	
Grouping categories	Doctor's responsiveness to verbal offers by patient rated under 4 categories/
Rating approach	Score of 0 to 3 for each offer. Final total divided by total number of patient offers.
Patient centred elements	1. Ignoring the offer
	2. using a closed question or direct answer preventing further exploration,
	3. using an open-ended response allowing the patient speak or explore further
	4. facilitating to express expectations, thoughts and feelings

Table 3.4: A summary of the three prominent rating scales used for measuring patient centeredness

3.6 Summary

The models of the consultation have focussed on different areas over time. Some have described approaches for consulting; for example recognising the therapeutic effect, behavioural dimensions and developing relationships. Others have adopted a predominantly task oriented view by describing tasks catalogues covering data collection, problem definition and problem management areas. Some have also analysed the contextual elements that may influence the consultation; for example time allocation, resource management and the physical environment.

Regardless of the orientation of the models, consultation tasks, associated interactions and the skills needed were acknowledged by most models. Reductionist methods have gradually become comprehensive holistic approaches. More contextual elements of consultation were mentioned by the newer models. Doctor-patient communication plays a significant role in achieving immediate consultation objectives as well as establishing a good social relationship which is instrumental in achieving wider benefits. Theoretical frameworks with holistic perspectives acknowledge both social and clinical realities of consultations. Comprehensive consultation research techniques have resulted in generating rich observational data with increased usefulness. Use of complementary qualitative and quantitative methods has been recommended as most appropriate to analyse clinical consultations.

Objectives and methods associated with consultation observation studies have progressively changed to provide more detailed analysis of consultation interactions. Early studies were mainly focused on understanding the consultation tasks. Verbal interactions were given more emphasis as a surrogate for doctor-patient communication. They were mostly based on the opinions of human observers or consensus amongst practitioners. Direct observation using audio recording methods were adopted subsequently. They resulted in providing repeatedly analysable, objectively collected observational data with durability. Video recording methods were then introduced to obtain a more comprehensive understanding of consultation processes. More recently, consultation studies have focused on exploring the consultation content in greater detail with increased focused on defining and prescribing consultation's content and exploring contextual elements.

Initial prominence associated with data collection stages has now transferred to analysis tasks; there is an increased emphasis placed on data processing to support more complex analysis of observations. Data analysis and representation methods have become technically advanced. Some studies have used graphical methods to convert the coded observations into more abstract representations. They have contributed to recognise consultation patterns effortlessly for further analysis or to support recognising overarching theories. This signifies the validity of sub hypotheses Hs4 to Hs7, where characteristics associated with the computer use is the focus. However, studies discussed in this chapter indicated more qualitative or subjective techniques, and are not readily usable. There is a dearth of tools capable of projecting the consultation tasks in a way that software engineers can easily incorporate them to system designs, or use for system evaluation. This demand is linked with the sub hypothesis H_{s8}, thus indicates the need for a developing a new process modelling framework.

This chapter informs the characteristics needed to assess the first two sub hypothesis (H_{s1} and H_{s2}). There is a lack of approaches capable of combing individual observational elements to deliver all-inclusive reporting outputs to support thorough and multi-faceted analysis of computerised consultations. Most of the studies on computerised consultations have looked into the occurrences of the computer use with less detail, about their precise objectives or influence. There are qualitative studies analysing the patterns or the impact on the consultation process. However, their underlying coding stages are more subjective. Consultation observation research methods contain common phases; starting from interaction observation to interpretation and representation of interaction meanings. Non-verbal interactions and the patients' involvement have also been incorporated in recent studies. Video recording based observation methods now provide all-inclusive view of consultation interactions. They are more deployable, cost-effective and supply adaptable research data sets. Next two chapters present the research design and development tasks carried out to meet the demands linked with the study hypotheses, based on the implications of the investigations described thus far.

CHAPTER 4

Technical method

4.1 Introduction

This chapter details the design agenda and the technical developments associated with the research method. Early investigations focused on exploring the state of the art pertaining to the existing approaches, tools and applications and their ability to evaluate the research hypotheses. Informed by this evaluation, a structured approach has been set to enhance and develop the technical aspects of the study design. A set of complementary software applications, data collection and processing techniques have been developed based on the design agenda. The technical design of this study chiefly considered three observable aspects of the clinical consultation;

(1) The consultation interactions – verbal, non-verbal and computer use,

(2) The subjects involved in interactions - doctor, patient, computer and other objects or features and (3) The consultation's environment – consultation room with its material features.

Based on the above three core elements, four development objectives have been established for the technical method. These objectives and their relationship to the individual sub hypotheses are stated below;

1. To develop a consultation observation technique capable of collecting data on the three facets described above – sub hypothesis Hs1
2. To define a recording apparatus that can be readily set up with least amount of modification to the consultation environment – sub hypothesis Hs2
3. To establish a data collection element with the capacity to measure interactions involved in consultation tasks, to support individual analysis and with capacity for synchronisation to view as a combined output – sub hypotheses Hs2 to Hs5
4. To establish an analysis approach capable of isolating any influence computer use is having on the consultation and with the capacity to provide precise information about the associated EPR system design features – sub hypothesis Hs6 to Hs8

4.2 Investigating the existing applications

Early evaluations to inform the technical design focused on four domains that deploy observational data analysis techniques;

1. Qualitative research
2. Conversation analysis using transcriptions
3. Usability testing in Human Computer Interaction (HCI) domains
4. Screencasting for video based demonstrations.

A summary of this evaluation step is presented in table 4.1. None of the evaluated applications could deal with multiple video inputs, which is vital to record consultation interactions with a comprehensive coverage. The two applications widely used for qualitative research, Atlas ti and

NVivo offer features for coding and classification of interactions based on an audio-visual recordings. However, they lack any data recording facilities or ability to support comparisons between multiple observations. Similarly, widely used transcription applications offer facilities to classify verbal interactions and analyse multiple observations, however without any quantitative measurements that can be standardised later.

Usability testing applications have features that can comprehensively represent doctor-computer interactions. Nevertheless, they do not offer features to reflect the totality of the consultation interactions. Moreover, usually they are complex to setup and most efficient when used along with '*think aloud protocol*'; asking users to verbalise their intentions behind the observed interactions. Screen casting applications provide recording features that are capable of capturing doctor's EPR use, and incorporate keyboard and mouse usage data. However, they do not have features to incorporate multiple video recordings of the consultation into a single analysable data stream. In general, the compared applications are either limited in their capabilities to offer comprehensive measurements on more than one aspect of interactions or do not have the capacity to compare multiples observations simultaneously. They also lack any analysis outputs that would be useful for the process modelling intentions of the study design.

Expected features	**Qualitative research**		**Transcription & analysis**	**Usability testing**	**Screen casting**		
	ATLAS.ti	**NVivo**	**Transana**	**Morae**	**Camtasia**	**Adobe Captivate**	**BB FlashBack**
Handle input from 3 cameras or combined video	1 video file. Limited view	1 video file. Limited view	1 video file. Limited view	1 webcam	No	No	1 webcam
Computer screen capture	No	No	No	Yes	Yes	Yes	Yes
Fast setup for recording & data export	No recording element	No recording element	No recording element	Complex setup	Moderate setup, large data file	Moderate setup, large data file	Moderate setup, large data file
Coding & measuring of interactions	Codes segments. Manually measure.	Codes segments. Manually measure.	Codes video clip. No measure.	Codes video frame. Manually measure.	No coding. No measure.	No coding. No measure.	No coding. Manually measure.
Simultaneous viewing of multiple observations	Limited view. All in one channel	Limited view. Multiple channels	Limited view. All in one channel	Limited view. All in one channel	No	No	3 observations only
Easy to compare observational data	Using network diagrams	Using nodes or networks	Using codes, collections	Using tables, graphs	No	No	No

Table 4.1: Evaluation of the existing applications against the design specification established for this study

4.3 Development of the work packages

As none of the existing applications could support the design specification comprehensively, the next stage of the research focused on constructing a new technical design for meeting the four development objectives. Based on the earlier stated development objectives and after considering the available resources, the author derived five work packages. In addition to the development framework and agenda established earlier, the scope of each work package was further influenced by the research studies that had already been conducted by the PCI team. Their contributions are separately discussed where appropriate. The work packages were associated with the following objectives;

1. To enhance the multichannel-video recording approach – easy to deploy recording hardware, reducing the cost, shortening the video processing steps and improving the usability of the video output.
2. To improve the multi-channel video coding stage - increasing its reliability, usability and ability to incorporate new interaction measurements.
3. To explore the possibilities to introduce objectivism - automated data collection techniques.
4. To develop an application capable of combining and synchronising observational data to support consultation task analysis
5. To establish an output specification and the necessary applications to generate analysable results with following characteristics;
    a. Quantitative measurements,
    b. Qualitative data,
    c. Exportable to different usable formats,
    d. Traceable to the original interaction,
    e. Navigable between different observational aspects,
    f. Supports abstraction of process models.

Following sections describe the developments carried out under each of the above work packages.

4.4 Time structured data recording

Quantitative data on the interaction durations are important to understand the consultation process and the distribution of time across the different constituent tasks. Similar approaches have been used in variety of ways in consultation analysis research; for example *consultation maps* detailing the progress of the consultation tasks along a time line and analysis tools like *Timer* where interactions are noted at regular intervals throughout the consultation. This research specifically aims to measure the amount of time a doctor spends using the computer. Furthermore, the durations of doctor-patient interactions and their variations are important to contextualise the data on computer use.

Due to the inherent complexity of the consultation interactions and their unpredictable nature, having accurate records of both the occurrence and duration of interactions is vital to the research objectives. Location of interactions relative to the consultation process flow is needed to compare the association between different interactions; their parallel or sequential nature, and inter-dependence. Therefore, the design of this research principally aimed to collect the observational data in a time structured manner. This applies to the coding of variety of interactions based on the consultation video and direct or indirect observational methods. The following formats have been established for the data collection;

- **Duration interactions** – [***event type, event value, start time, end time***]
- **Momentary interactions** – [***event type, event value, time***]

The order of the parameters or the formats of the time values are not strictly specified. Instead it was decided to have a common processing stage to standardise different log file formats, subject to the existence of the essential parameters specified above. This is decided considering the potential differences in the log-files created by other external applications, and to allow collaboration with other studies. This common processing stage is described later.

4.5 Developing the multi-channel video recording apparatus and method

The video recording based observation of consultations is a two step process;

1. **The video recording stage** – preparing the recording equipments, setting them in the consultation room, recording the session/s and removing the equipments.
2. **Video production stage** – extracting the video from the recording medium and preparing them for the analysis stage.

4.5.1 Previous developments of the consultation video recording technique

The progressive development of the video recording techniques could be classified under five stages. The progressions up to stage four occurred before the start of this research study. They are detailed in table 4.2.

There have been further experiments with an additional video channel focusing only on the doctor's face and a new format of multi-channel video where clicking on a selected channel would enlarge that to a full size view. However, the multi-channel approach with three cameras and the screen capture has been recognised as having sufficient usability (Leong, 2006). In the multi-channel setup, cameras are mounted on individual tripods and positioned in the consultation room to record the three separate angles as clearly as possible. There are additional setup tasks for preparing the recording equipments and maintaining their readiness throughout the recording session.

Hardware profile and description	Effectiveness and limitations
Stage-1 (Singe channel) Single camera with a wide angle view covering the doctor, patient and computer. Videos rated using an eight point scale. (de Lusignan et al, 2002)	• No clear view of the doctor's interactions with the computer • Requires to showing the computer screen and questioning the user to interpret the interactions • Difficult to measure precise length of interactions due to analogue video and use of stop watch method
Stage-2 (Three channels) Two cameras and screen recording of the computer. Camera 1 – wide angle view as stage-1. Camera 2 – doctor's upper body. Use of professional recording equipments (Theadom et al, 2003)	• High quality view • High cost • Intrusiveness due to dedicated recording hardware, cables and operator • Not readily deployable • possible to synchronise – in a studio
Stage-3 (Three channels –low cost) Same as stage-3 but with low cost equipments - Sony DCR HC35 MiniDV cameras. Screen capture using Camtasia studio V3.0. Videos synchronised and mixed using Adobe Premier Elements (Sheeler et al, 2007)	• Low cost and less intrusive hardware. Quality of the output similar to stage 2 • Requires changing recording medium if used for longer periods • Video output not readily usable, extra format conversion steps • Difficult to interpret the involvement and responses of the patient
Stage-4 (Multi channel) Three cameras with screen capture. Additional camera introduced to stage-3 setup. Camera 3 – focusing on the upper body of the patient	• Sufficient details recorded about verbal and non-verbal interactions, computer use. • Takes longer for post recording processing. • More difficult to manage the availability of recording medium due to increased number of camera • In the final output part of the screen capture covered by the three videos from the cameras

Table 4.2: Progressive developments of consultation video recording techniques

4.5.2 Optimising the video recording hardware profile and the task improvements

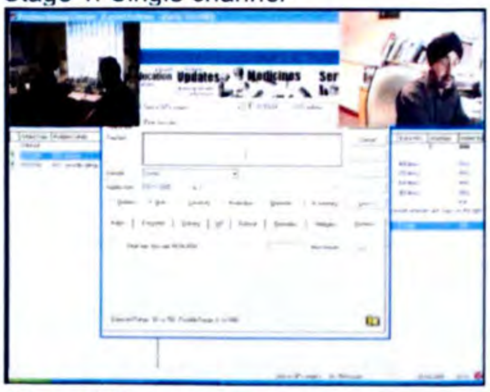
Despite the positive features of the stage-4 MCV setup, challenges remained in the video recording stage. They are;

- Using tapes as the recording medium provides less recording time.
- During a recording, the availability of the recording medium's space requires monitoring.
- Loading a new tape means interrupting the clinician during the surgery session, and impact is particularly significant if required to do so for all three cameras.
- Screen capture using Camtasia demands processing power and disk space of doctor's computer, this could place demands on doctor-computer interactions

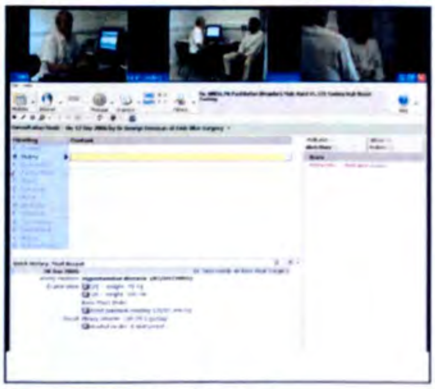
In general, the MCV Stage 4 specification though readily deployable, is demanding during the recording phase with potential intrusions in to the consultations.

Stage 1: Single channel

Stage 2: Three channel - professional



Stage 3: Three channel – low cost



Stage 4: Multi-channel

Figure 4.1: Development stages of the multi-channel video recording method

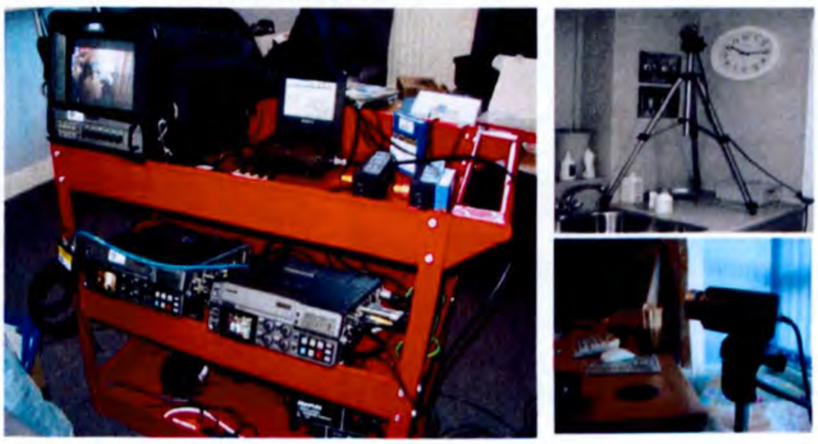


Figure 4.2: Professional recording equipments used in the stage-2 setup

To overcome the above challenges, after evaluating a range appropriate technologies the following improvements have been introduced to the multi-channel video recording's technical specification.

1. **Video cameras with hard drive based recording medium** - Video cameras with magnetic hard drive based (HDD) recording medium (JVC Everio MG330) are smaller than the earlier MiniDV tape based versions and have more recording capacity (up to 14 hours). They do not require monitoring of disk space and have less profile within the consultation environment.
2. **Power supply using high capacity batteries** – This eliminates the need for setting up or removing of the mains power supply, and absence of power cables reduces the profile of the recording.

3. **Hardware based screen capturing method** – This provides a direct video feed of the doctor's computer into a separate laptop. It eliminates the need for software installation and downloading of recorded files from the doctor's computer.
4. **Compatible video outputs from the recording channels** – Both the hardware based screen capture application (VGA2USB) and the chosen type of video cameras provide the video files in MPEG-2 format. They can be imported directly to the video mixing application without needing to do any format conversions. Compared to the stage-4 setup, this saves about one hour of processing time per a consultation video.

4.5.3 Improvements to the post recording processing

The post recording processing includes the tasks starting from the downloading of the consultation video recording, up to the generation of a multi-channel video output, ready to be rated by a researcher. This consists of two stages;

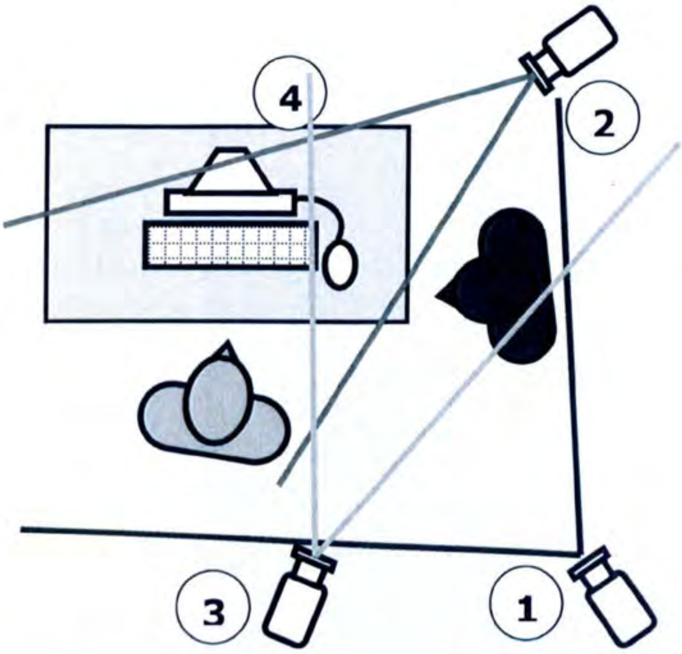
1. **Preparing the videos for multi-channel video production** –Tasks related to downloading of the video files from the screen capture and three cameras, performing the necessary format conversions (not needed in the improved setup) and grouping of the video files associated with the same consultations together.
2. **Production of the multi-channel video** –Importing of the four video files to the video mixing application (*Adobe Elements*), resizing and positioning the four video files to the standard multi-channel format, synchronising the audio and video channels, marking up the correct consultation start/end time and rendering the project to obtain the final synchronised multi-channel video.

The improvements introduced in to the recording setup resulted in eliminating a number of processing steps for video preparation. These improvements are as below;

- **Removing the need for format conversions** – Stage-4 MCV setup produced two different video file formats during the consultation recording; *Camtasia* screen recorder produces AVI format files, while the video cameras produce files in DIV format. Solving this incompatability in file format required an additional application (*Sorenson Squeeze*) and time to go through the format conversion process- about 45 minutes for a 15 minute consultation.
- **Faster transferring of video files** - The tape based cameras required rewinding and transferring the videos into a separate computer with a *FireWire* type interface to download the video files. This needs to be repeated three times, and takes about 30 minutes for a single consultation. With the use of HDD based cameras, videos can be directly transferred across using a standard USB connections
- **Best practice routine for video synchronising** – The author created a new user manual describing the most efficient technique for synchronising the four video channels. Video synchronising is a critical stage of the process; a poorly synchronised video reduces its usability for interaction analysis. Nevertheless, the amount of preparation and experience determines the perfection of this particular stage of the preparation.
- **Layout of the multi-channel video output** – The new layout offers unobstructed display of all four video channels compared to the stage-4.

(1) Preparing the tripods **(2)** Mounting the cameras and positioning them **(3)** connecting the screen recorder to doctor's computer **(4)** Connecting the screen recorder output to a laptop **(5)** Ready for recording

Figure 4.3: The multi-channel recording's setting up process



(1) – Wide angle view including doctor, patient and computer screen
(2) – View of doctor's upper body including face and hands
(3) - View of patient's upper body including face and hands
(4) - Screen capture to record the computer screen

Figure 4.4: The multi-channel recording setup in a consultation room

Wide angle view
This should have the doctor, patient and the computer in its view. The camera capturing the wide angle shot should have a clear view of the doctor's computer screen. This is important for synchronising the cameras footages with the screen recording

View of the doctor
This is a view of the doctor's upper body from the patient's eye level. This should cover doctor's upper body and the computer keyboard.

View of the patient
This is a view of the patient's upper body. It is important to capture patient's hands.

Figure 4.5: The three views of the consultation recorded by the video cameras

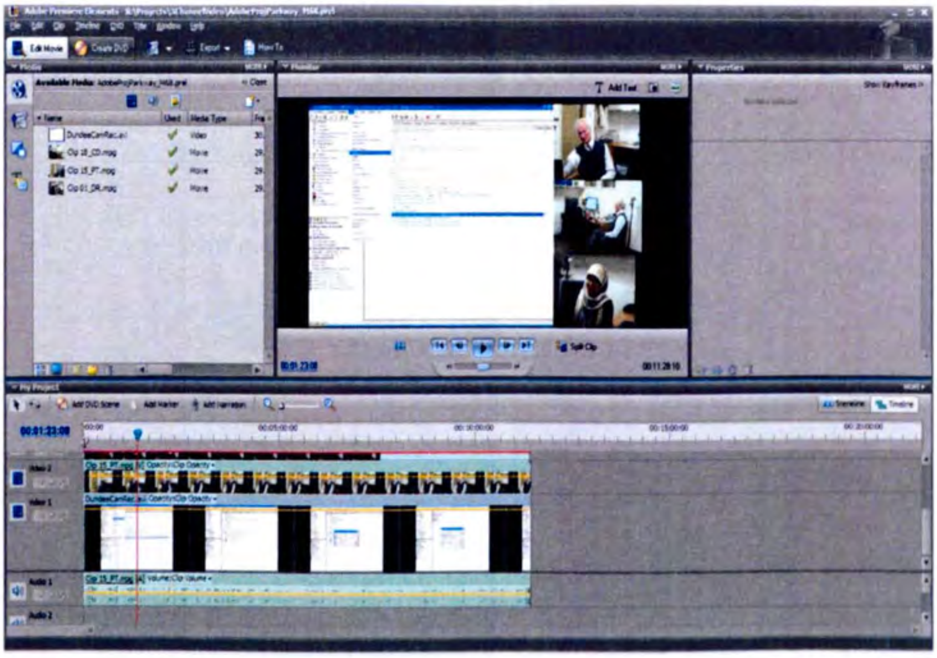


Figure 4.6: Synchronising and mixing of the four video channels to produce the multi-channel video in Adobe Premier Elements

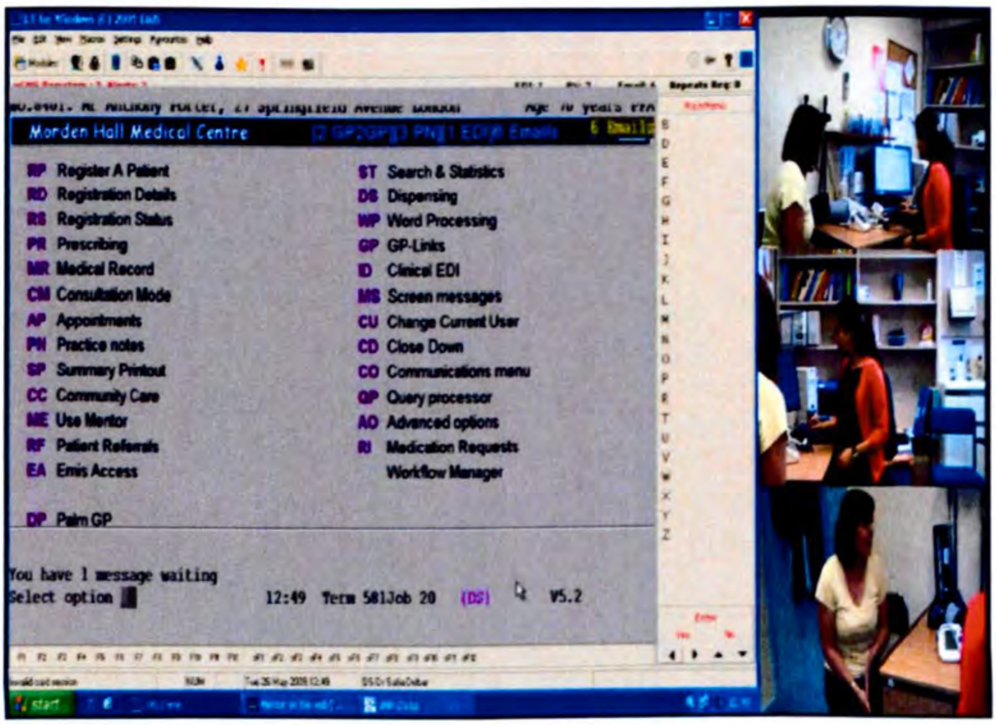


Figure 4.7: The multi-channel video - ready for the observation stage

Hardware profile	Cameras – JVC Everio MG330 30 GB Tripods – Manfrotto 682B – Monopods with legs Screen recorder – VGA2USB frame grabber LR Laptop (for saving storing screen capture) – Standard laptop with minimum of 30GB hard drive and USB interfaces
Software applications	Windows Media Player or MPEG-2 compatible video player Adobe Premier Elements or similar multimedia production application
Multi-channel video display settings	Screen capture: X=353.6, y=288, 100% from original size Patient view: X=840, y=479.3, 33% from original size Wide angle view: X=840, y=288, 33 % from original size Dr view: X=353.6, y=98.9, 33 % from original size
Multi-channel video production settings	File Type: MPEG 1 TV standard: PAL Frame size : 960 x 576 Frame rate: 25fps Video quality: 5.0 Pixel aspect: 0.9157 Audio: 128kbps, 48KHz, 16 bit mono Bitrate encoding: CBR 4Mbps

Table 4.3: Technical specification of the current multi-channel video setup

4.6 Coding of the consultation interactions

The prerequisites for identifying and coding the multitude of interactions observable in a consultation have been established by earlier discussions presented in this thesis. Malterud (1996) and Bailey (2008) particularly reflected on the value of this phase of the research. As reported earlier, a number of other studies adopted various classifications of interactions and tools to facilitate the subsequent phases. For example, Kaner et al(2001) used the Observer software and Pearce et a (2009l used the Gamebreaker application to do this initial interaction coding activity. The following section describes an initial approach used by the PCI research team and the development of a novel application by the author based on the lessons learnt.

4.6.1 Use of ObsWin™ for coding of consultation interactions

ObsWin is regarded as an application for collection and analysis of observational data (Martin et al, 1998, Kahng and Iwata, 1998). It can be used to code observations in a video file as momentary events or as durations of activities. The latter type had been used to mark the durations of various consultation interactions in early pilot research studies conducted by the author and other researchers in the PCI team. To code an interactions occurrence, a rater has to mark the start and the end time by pressing and releasing a designated keyboard key. Ratings activities are stored in a separate log file with each row of data representing the value of the variable, the start time (onset) and the end time (offset). This output can be then viewed as a frequency table, as bar charts or as an 'occurrence graph'.

Occurrences of coded activities, represented by black rectangles are visible as parallel activity lines in the occurrence graph. This graphical representation has been useful in understanding the occurrences of different interactions within a computer assisted consultation, their overlapping or mutually exclusive nature and the sequence of events.

The activity coding process usually involves minimum of two viewings of the video; first one without any rating to familiarise with the video and the subsequent viewings are to code the activities. The actual number of viewings is determined by the amount of variables and the nature of the interactions they represent. For example, it is difficult to code *'doctor looking at patient'*, and *'doctor talking to patient'* interactions at the same time, as they tend to happen in-tandem.

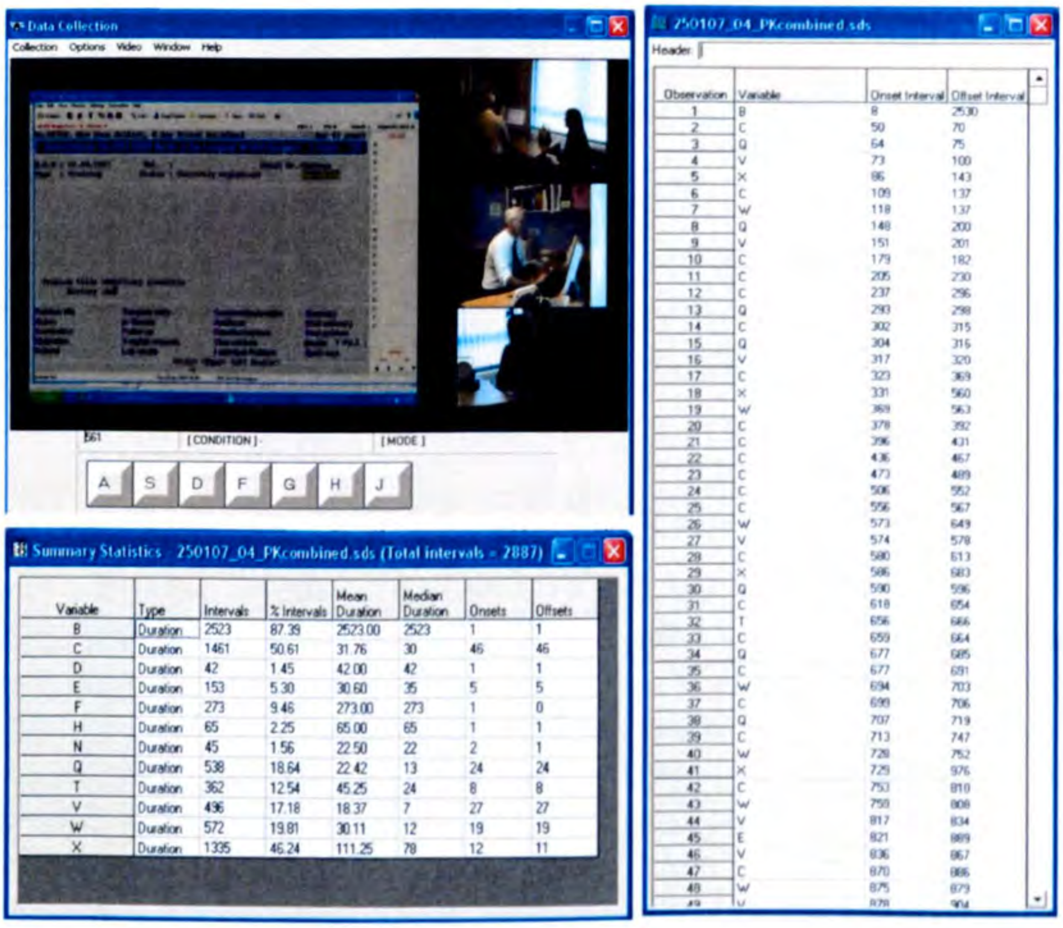


Figure 4.8: The ObsWin coding interface (top left) and two data outputs – event occurrence table (right) and the event frequency table (bottom left)

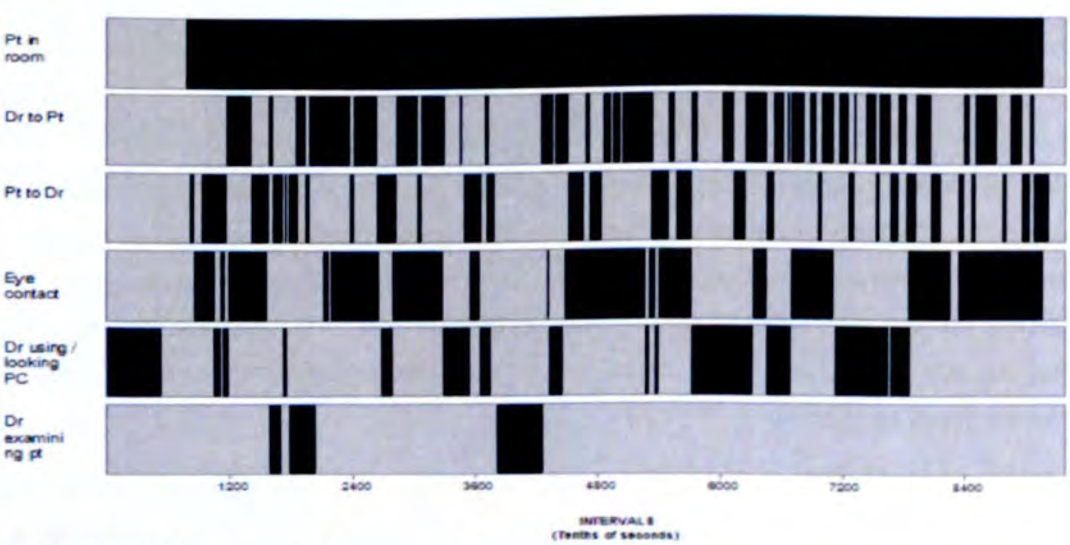


Figure 4.9: The ObsWin Occurrence graph output

4.6.2 Limitation and challenges for interaction coding using ObsWin method

ObsWin has been used as the main observational coding mechanism for majority of the consultation observation research conducted by the PCI team, and also the initial approach used by the author for various pilot projects. All through its use, following limitations of ObsWin have been recognised.

1. **Limitation of the main consultation video display area** –The main display areas is shared between the video player and the panel for interaction key representations.
2. **Poor indication of the active/inactive status** – The interaction keys represented in the bottom of the display area partially changes its border colour to indicate the pressed/released status of the key. This is hard to notice during a rating episode.
3. **Lack of movie playback controls** – The playback controls are not fully functional during the rating. Pressing the pause button often results in erasing the collected data. It is not possible to move backward and restart the rating from mid-point.
4. **No reminders on rating variables** – In situations where multiple rating variables are being used, it is useful for the researcher to have variable labels to remind the link between the character key and the interaction type.
5. **Difficulty in marking the precise time durations for computer screen activities** – If clearly defined, the doctor-computer interactions where the progress of the activity is visible on the screen recording can be marked precisely, by pausing the movie and playing it step-wise forward or backward using the playback controls. Not having this feature often requires rating the same video multiple times.
6. **Data not visible until the completion of the rating** – It is useful to monitor the accuracy of rating half way through. ObsWin displays results only after completing the rating process
7. **Run-time errors** –Certain run-time errors are triggered during heavy usage. This usually requires re-starting of the computer.
8. **Difficult to edit rating values** – There are occasions where rating values need to be corrected to rectify obvious errors, for example when the on/off status is mistaken. If positively identified, editing the file might be easier than re-rating the video.

4.7 The Observational Data Capture (ODC) application

In order to overcome the limitations associated with the ObsWin based approach, it was decided to develop an alternative video observation platform. This development task primarily aimed to improve the reliability of the rating stage. The potential to have a flexible application that can be customised based on project requirements, with capacity to deal with larger sample sizes and increased usability also substantiated this decision. it was decided to create a replacement for the ObsWin approach. The author designed and developed a new tool, the Observational Data Capture (ODC) application using Java programming language. Features of Java Media Framework (JMF) was utilised for this. The development environment used was NetBeans.

Based on the earlier experience from using the ObsWin, due to the pragmatic concerns pertaining to the rating activities and considering the potential for improving task efficiency and reliability, existence of three types of interaction identifiers have been recognised as the basis for the ODC tool's architecture;

- **Singleton interactions** – Interactions that usually occur once during a consultation. After having watched the consultation video once, occurrence of singleton type interactions can be located with minimum effort.
- **Episodic interactions** – These interactions are associated with certain stages of the consultation. With a moderate level of familiarity with the content of the consultation, often their occurrences can be predicted. Consequently a rater can go to a known segment of the video directly to mark their durations instead of watching the entire length of the video. For a given type of episodic interactions, it is possible to presume associations between the durations of two adjacent occurrences.
- **Continuous interactions** – Interactions that are likely to occur throughout the consultation. Their occurrence is often difficult to predict, durations vary with no apparent relationship between adjacent events. They can only be rated by watching the entire length of the movie.

ODC application provides two separate rating approaches aligned with the three types if interaction identifiers;

(1) *Segmental data capture* interface to rate Singleton and Episodic type interactions

(2) *Continuous data capture* measure continuous type interactions.

Variable type	Properties	Examples
Singleton	Generally occurs once	Blood pressure measurement Prescribing Referral Physical examination
Episodic	Separate sections of interactions Less frequent Durations more predictable or relatively easy to observe	Coded data entry Free text data entry Navigation Prompts and alerts Interruptions Screen sharing
Continuous	Distributed throughout the consultation Occurs frequently Unpredictable durations or difficult to define	Gaze Speech Computer use – key board, mouse Looking at computer screen

Table 4.4: Continuous and episodic variables in the consultation

This modular design offers flexibility to the raters and enables them to focus only on the functionalities associated with the ongoing activity. Following are the main interface elements of the ODC application.

- **The main project window** – This is the starting point for a rating project. After selecting the video file to rate, based on the type of rating activity (i.e. continuous or episodic) the appropriate set of information needs entering. For rating with continuous variables, the next steps are selecting the desired keyboard character keys and the entering of their labels. To maintain the efficacy of rating, the number of continuous variables is limited to a maximum of five. For the episodic rating, the variable names are loaded from a list stored in a text file. The two data views in the bottom area display the ongoing rating activity, they are editable text fields.

- **The video player** – This is an independent, movable and re-sizeable window. It has a progress bar to control the position of the movie and basic movie controls.
- **Rating panel 1, for continuous data capture** – This also is an independent, movable interface. Based on the number of variables selected in the project window and their character values, the rating symbols are displayed. The colour of the label represents the pressed/released status of each character. It has controls to pause, reset and restart the rating activity. The time value corresponding to each movie control is also displayed for verification purposes.
- **Rating panel 2, for episodic/singlton data capture** – Once the precise start and end times are marked using the movie controls or the function keys, user can then select the type of the interaction from the drop down list and supply any useful comments. For example, after selecting the interaction type as 'coded entry' and the exact code entered by the doctor can be supplied as a comment. This also offers pause, reset and re-start facilities.

The ODC application creates two types of outputs; '.txt' and '.csv' format files. They can be directly used with most statistical analysis packages or with MS Excel for quantitative analysis. Each entry represents the start and end time of the interaction, and the associated interaction variable. The episodic interaction log file, has an additional column representing the *comments* field.

ODC tool has resolved majority of the limitations identified in the Obswin approach. Furthermore, it introduces efficiency gains by increased usability, separation of interaction types, improved movie controls and editing facilities. More importantly, being an in-house development, its design is customisable to meet research needs.

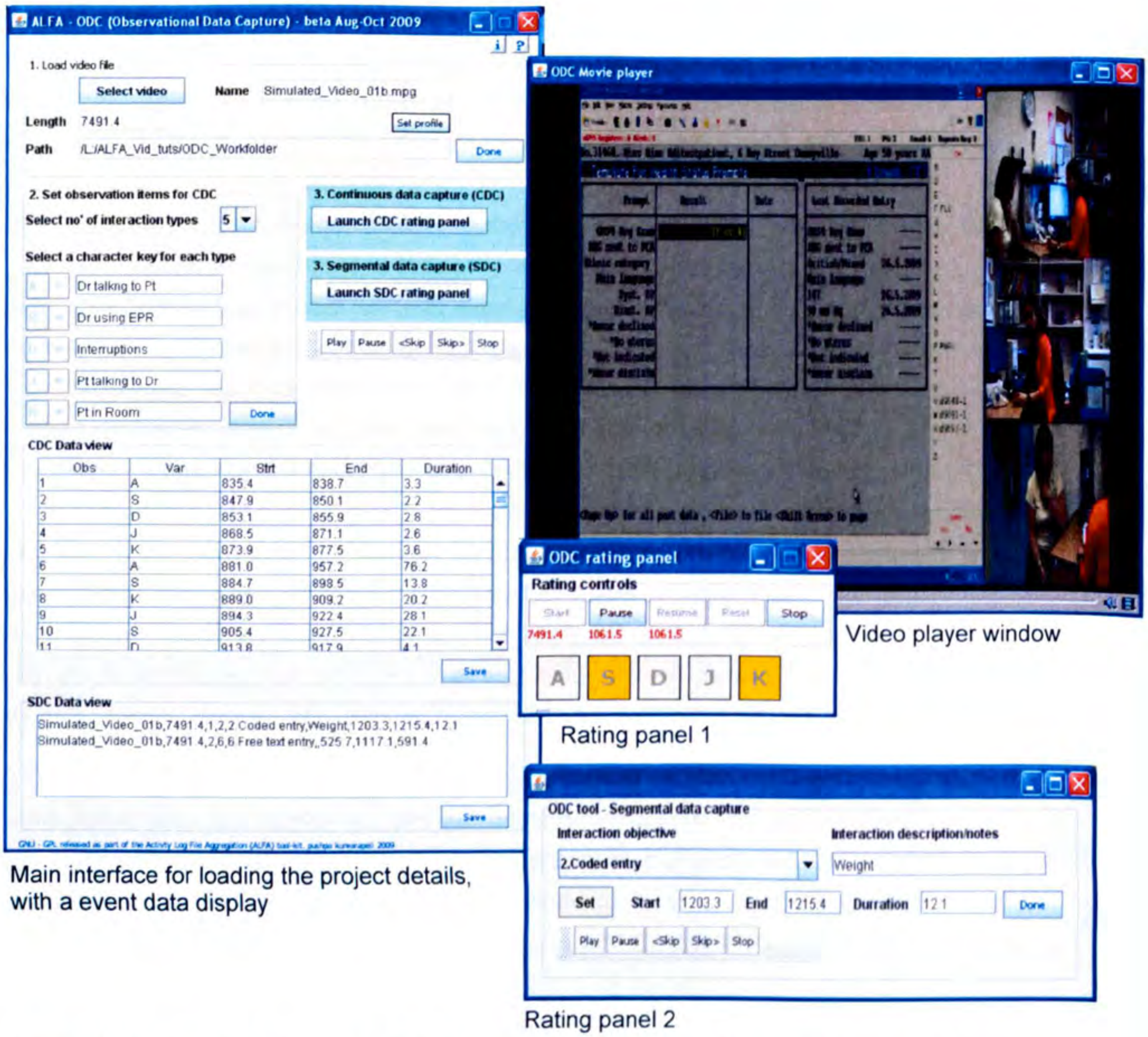


Figure 4.10: The ODC interfaces – Only the video player and one of the rating panels are used during rating

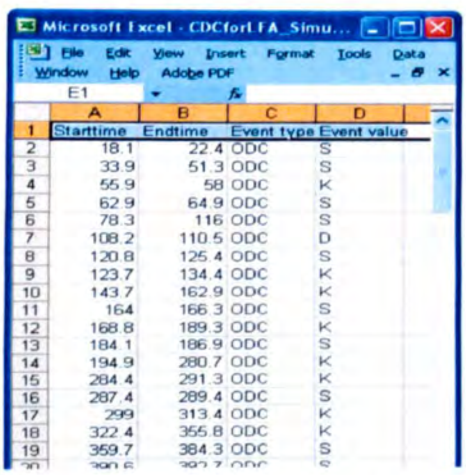


Figure 4.11: The event log file output generated by the ODC

4.7.1 Grouping of ODC continuous variables for rating runs

It is not practical to include all rating variables into a single rating run. They need to be grouped, and this should be carried out mostly considering the pragmatic concerns. They are;

1. **Relationship between the interactions under observation**
   It is more efficient to group the interactions that are less likely to overlap. For example, 'Doctor looking at the screen' variable is better grouped into the same rating run with 'Doctor-Patient eye contact' instead of having it with 'Doctor using the keyboard'.
2. **Location of the associated character keys on the keyboard**
   There are cognitive advantages of using two groups of character keys that are located in separate halves of the keyboard at the same levels. For example selecting keys 'S' and 'D' from the left and 'K' from the right half of the keyboard.
3. **Understanding from pilot or initial rating attempts**
   During the rating process, the suitability of the selected keys can be assessed based on the initial experience of the raters. It is difficult to guess the raters' ability to remember character keys or how they might cognitively associate the position of keys with the interaction they observe. Frequency of interactions is also difficult to anticipate beforehand.

4.8 Additional applications developed to supplement the data capturing

There are practical and research advantages of using objective approaches for collecting data on doctors' computer use. Interactions between doctor and computer are central to the problem domain of this research. As indicated in the literature review section, most studies have explored the computer use dimension using qualitative approaches. It is feasible to measure certain aspects of computer use by monitoring the functioning of computer peripherals. They have the potential to assist consultation research by following means;

- Introduces objectivity to data collection
- Quick comparisons or analysis can be performed
- Provides a summary view of doctor's computer use pattern
- Offers an outline based on which the other verbal and non-verbal interactions could be explored and compared
- Provides precise start and end times for computer interactions, which are useful as reference points to verify the durations of non-computer use interactions

4.8.1 The User Action Recorder (UAR) application

The UAR has been developed as an activity monitoring application. This needs installing in the doctor's computer before initiating the observation session. When activated, it constantly monitors the doctor's interactions with the computer mouse and keyboard. The author designed and developed this application using Microsoft Visual Basic. It is a relatively small application (only 32 kilobytes) placing unnoticeable levels of process demands on the clinical system. It reports the doctor-computer interactions by recording two separate time structured data logs. Its reporting structure is described in box 4.1.

Figure 4.12: UAR applications interface

UAR's interaction recording gets triggered only if an activity in either of the peripheral devices occurs. This keeps the size of the log file manageable compared to similar applications that record interactions at regular intervals. A typical 15 minute consultation using a EPR system with a graphical interface produces a log file of about 200 kilobytes. Both activity log files have two data columns; for event time and event descriptor. The mouse activity recognised by the UAR also include mouse clicks, however to make the mouse log-file usable for calculations these interactions are reported in the key log-file. Log-files are by default saved into the computer's 'C' drive and needs downloading at the end of the recording session.

Key activity log file	**Time column**; hour:minute:1/100 seconds **Event column**; Character keys : A to Z, a to z Numeric keys: 0 to 9 Navigation keys: Arrow keys as – 'DownA', 'UpA', 'LeftA', 'RightA' Other keys – 'BackSpace', 'Enter', 'Delete', 'Space' Mouse clicks – 'LeftClick','RightClick'
Mouse activity log file	**Time column**; hour:minute:1/100 seconds **Event column**; Coordinates of the mouse pointer : X axis value and Y axis value

Box 4.1: Reporting format specification of the UAR application

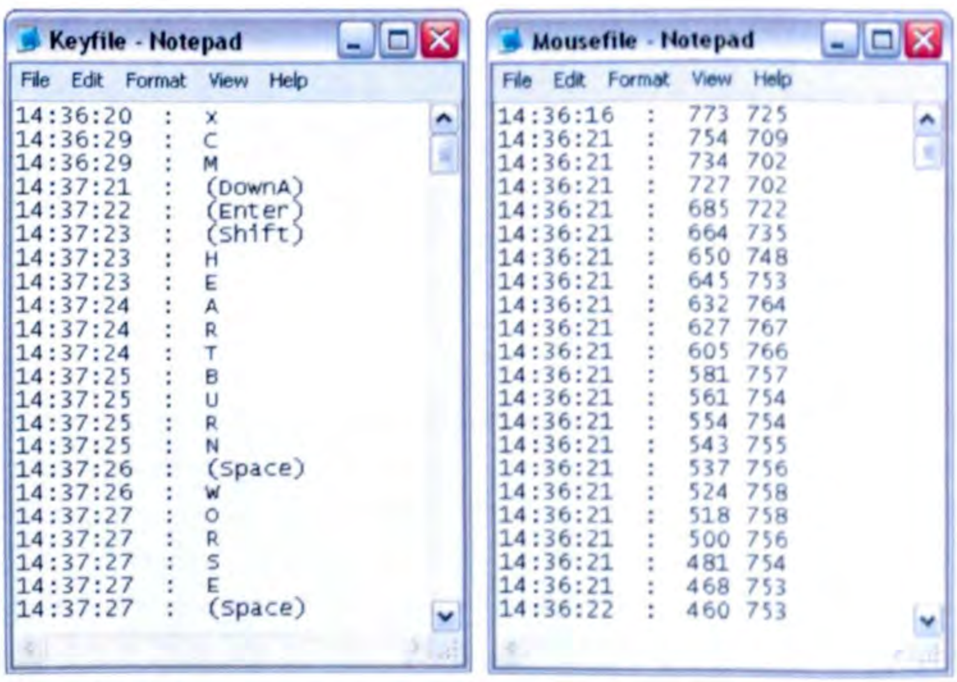


Figure 4.12: The key and mouse use log files created by the UAR application

4.8.1.1 Processing of UAR outputs

Outputs generated by the UAR can be directly imported into MS-Excel. A UAR data processing application author created using MS-Excel's Macro language can produce summary statics for computer use based on these two log-files. It produces a summary of keyboard use; total number of key presses are categorised as character, numeric, navigation, correction and 'enter' keys. Summary of the mouse activity file reports the number of recorded events per second and distance the mouse pointer has moved. Mouse travel distance is reported in pixel values, calculated using the 'Pythagorean equation' by comparing the X:Y coordinate changes within a second.

A comparison between UAR outputs from twelve simulated consultations with four different EPR systems each used by a separate GP user, suggested four seconds as a reliable measure to separate two adjacent segments of doctor-computer interactions. That is, if the time log values for two nearby events are less than four seconds, they are likely to represent a single episode of doctor's interactions with keyboard or mouse. The author established this threshold value by manually comparing UAR log entries against different values as the minimum possible duration between two adjacent events (Figure 4.13).

If analysed with an understanding about interface features, navigation mechanisms, functional areas and function keys of an EPR system, the key log file is useful to derive precise start and end times for meaningful interactions. This approach has been used in a pilot study with simulated consultations (Refsum et al, 2008)

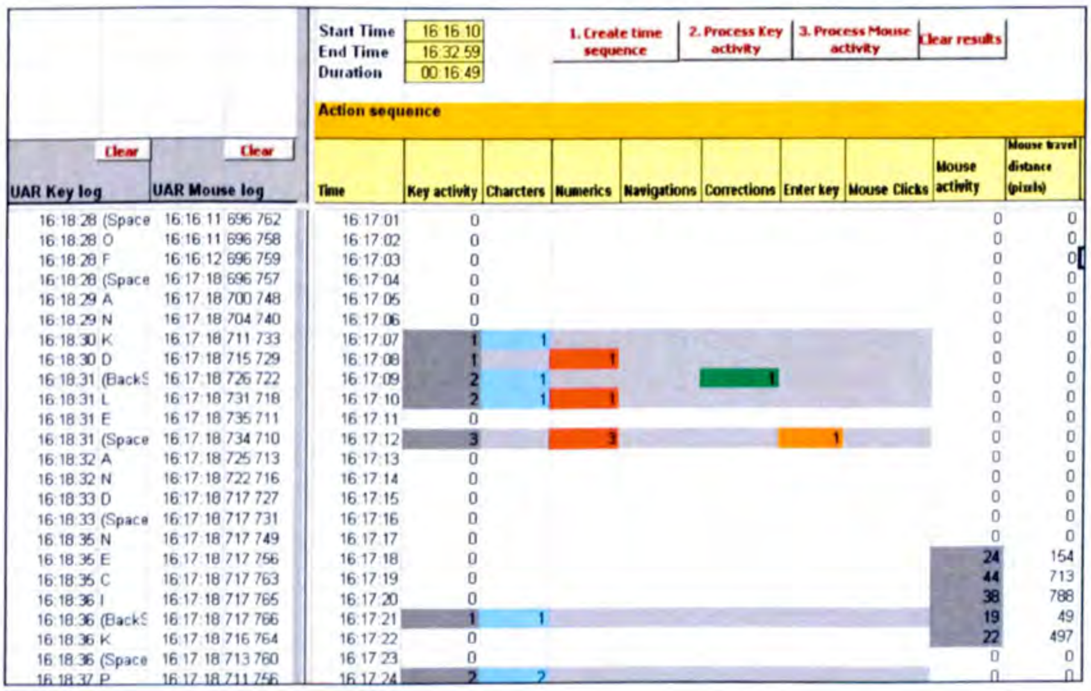


Figure 4.12: Processing the UAR outputs to create keyboard and mouse use summary data

	Time stamp	Action	Diff from start	Diff from previous	>1min	>2s	>3s	>4s	Activity	Duration
335	16:28:38	(Enter)	1:30:24	0:00:01	0	0	0	0		0:00:51
336	16:28:39	(UpA)	1:30:25	0:00:01	0	0	0	0	Coded: hypertensio[illegible]	
337	16:28:39	(UpA)	1:30:25	0:00:00	0	0	0	0		
338	16:28:39	(Enter)	1:30:25	0:00:00	0	0	0	0		
339	16:28:40	H	1:30:26	0:00:01	0	0	0	0		
340	16:28:40	Y	1:30:26	0:00:00	0	0	0	0		
341	16:28:41	P	1:30:27	0:00:01	0	0	0	0		
342	16:28:41	E	1:30:27	0:00:00	0	0	0	0		
343	16:28:41	R	1:30:27	0:00:00	0	0	0	0		
344	16:28:41	T	1:30:27	0:00:00	0	0	0	0		
345	16:28:41	E	1:30:27	0:00:00	0	0	0	0		
346	16:28:42	N	1:30:28	0:00:01	0	0	0	0		
347	16:28:42	S	1:30:28	0:00:00	0	0	0	0		
348	16:28:42	I	1:30:28	0:00:00	0	0	0	0		
349	16:28:43	O	1:30:29	0:00:01	0	0	0	0		
350	16:28:43	N	1:30:29	0:00:00	0	0	0	0		
351	16:28:43	(Enter)	1:30:29	0:00:00	0	0	0	0		
352	16:28:45	A	1:30:31	0:00:02	0	0	0	0		
353	16:28:45	(Enter)	1:30:31	0:00:00	0	0	0	0		
354	16:28:46	E	1:30:32	0:00:01	0	0	0	0		
355	16:28:48	(Enter)	1:30:34	0:00:02	0	1	0	0		0:00:09
356	16:28:52	N	1:30:38	0:00:04	0	1	1	0		
357	16:28:52	(Enter)	1:30:38	0:00:00	0	0	0	0		
358	16:28:53	(DownA)	1:30:39	0:00:01	0	0	0	0	[illegible]	
359	16:28:53	(DownA)	1:30:39	0:00:00	0	0	0	0		
360	16:28:53	(Enter)	1:30:39	0:00:00	0	0	0	0		
361	16:28:54	A	1:30:40	0:00:01	0	0	0	0		
362	16:28:55	B	1:30:41	0:00:01	0	0	0	0		
363	16:28:55	E	1:30:41	0:00:00	0	0	0	0		
364	16:28:55	N	1:30:41	0:00:00	0	0	0	0		
365	16:28:56	D	1:30:42	0:00:01	0	0	0	0		
366	16:28:56	R	1:30:42	0:00:00	0	0	0	0		
367	16:28:56	O	1:30:42	0:00:00	0	0	0	0		
368	16:28:57	V	1:30:43	0:00:01	0	0	0	0		
369	16:28:57	(BackSpac	1:30:43	0:00:00	0	0	0	0		
370	16:28:57	F	1:30:43	0:00:00	0	0	0	0		
371	16:28:58	L	1:30:44	0:00:01	0	0	0	0		
372	16:28:58	U	1:30:44	0:00:00	0	0	0	0		

250107_06 / 250107_4

Figure 4.13: Processing the UAR outputs to obtain a threshold value to recognise events representing uninterrupted doctor-computer interactions

Microsoft Excel - Book2

	Time	Interval	Video time	D	E	Coded or free text?	QOF related?	Template entry?
2	15:21:13	00:00:00	636	T	Goes into epilepsy template	Coded	Yes	Yes
3	15:21:18	00:00:05	641	R				
4	15:21:19	00:00:01	642	(Enter)				
5	15:21:21	00:00:02	644	(DownA)				
6	15:21:22	00:00:01	645	(DownA)				
7	15:21:23	00:00:01	646	(DownA)				
8	15:21:24	00:00:01	647	(DownA)				
9	15:21:24	00:00:00	647	(UpA)				
10	15:21:26	00:00:02	649	(DownA)				
11	15:21:33	00:00:07	656	B	Fit free>12 months			
12	15:21:34	00:00:01	657	(Enter)				
13	15:21:36	00:00:01	658	(Enter)	Moves down to next field	Coded	Yes	Yes
14	15:21:46	00:00:11	669	Y	Last fit			
15	15:21:48	00:00:02	671	1				
16	15:21:48	00:00:00	671	4				
17	15:21:49	00:00:01	672	2				
18	15:21:50	00:00:01	673	2				
19	15:21:51	00:00:01	674	0				
20	15:21:51	00:00:00	674	0				
21	15:21:52	00:00:01	675	5				
22	15:21:53	00:00:01	676	(Enter)	Complete entry of last fit date			
23	15:22:07	00:00:14	690	8	Enters number of units of alcohol	Coded	No	Yes
24	15:22:07	00:00:00	690	(Enter)				
25	15:22:08	00:00:01	691	(Enter)		Coded	No	Yes
26	15:22:09	00:00:01	692	Y	Records alcohol advice given			
27	15:22:10	00:00:01	693	(Enter)				

Chart1 / Sheet1 / Sheet2 / Sheet3

Figure 4.14: Manual processing the UAR outputs to identify the specific purposes for computer use

4.8.2 The Voice Activity Recorder (VAR) application

Coding of verbal interactions is generally reliable (Moulene et al, 2007, Refsum et al, 2008). However, to increase the efficiency of the coding stage, the author explored the possibility of obtaining automated measurements of verbal interactions. Noldus et al (2000) have used a software programme called '*Observer*' to process digitised audio recordings to distinguish 'utterances' and report their durations. The RIAS approach for coding medical dialogues also uses the utterance as the conversational unit. An utterance is considered as "any stretch of talk by one person, before and after which there is silence on the part of that person" (Schiffirin, 1987)

The VAR tool was developed to obtain objective measurements of the speech during a consultation. This creates a log file by analysing the sound levels of a recorded video. Certain amount of noise reduction can be done by adjusting the silence and gain levels. Setting the sample size adjusts the overall sensitivity of the tool to the voice levels. Its output is a log file with time-stamps indicating possible start and end times of verbal interactions.

The author initially researched for a software technique capable of differentiating doctor's and patient's voices. However, existing '*voice recognition*' applications are difficult to use due to the variations in consultation room layouts, intrusiveness of dedicated voice recording hardware, lack of control on the patients seating position and time constraints. VAR application uses the Java Sound API to measure the amplitude of a sound wave sample to distinguish possible verbal interactions.

The availability of VAR log improves the creation of consultation transcripts. Transcribers can type the text against a corresponding time-stamp provided by the VAR. This provides a time-stamped transcription which can be synchronised with any of the other observations.

It is also possible to use VAR to identify who initiates and terminates silence. Pilot studies indicated how doctors sometimes make purposeless use of the IT to initiate silence to control the consultation. The format of the VAR log is designed to be compatible with widely used transcribing tools, and it is easily customisable. It has header fields which details the format of the data recording. The author has successfully imported time-stamped transcriptions into the 'Subtitle Worksop' application, which enabled linking of the VAR outputs directly with video segments.

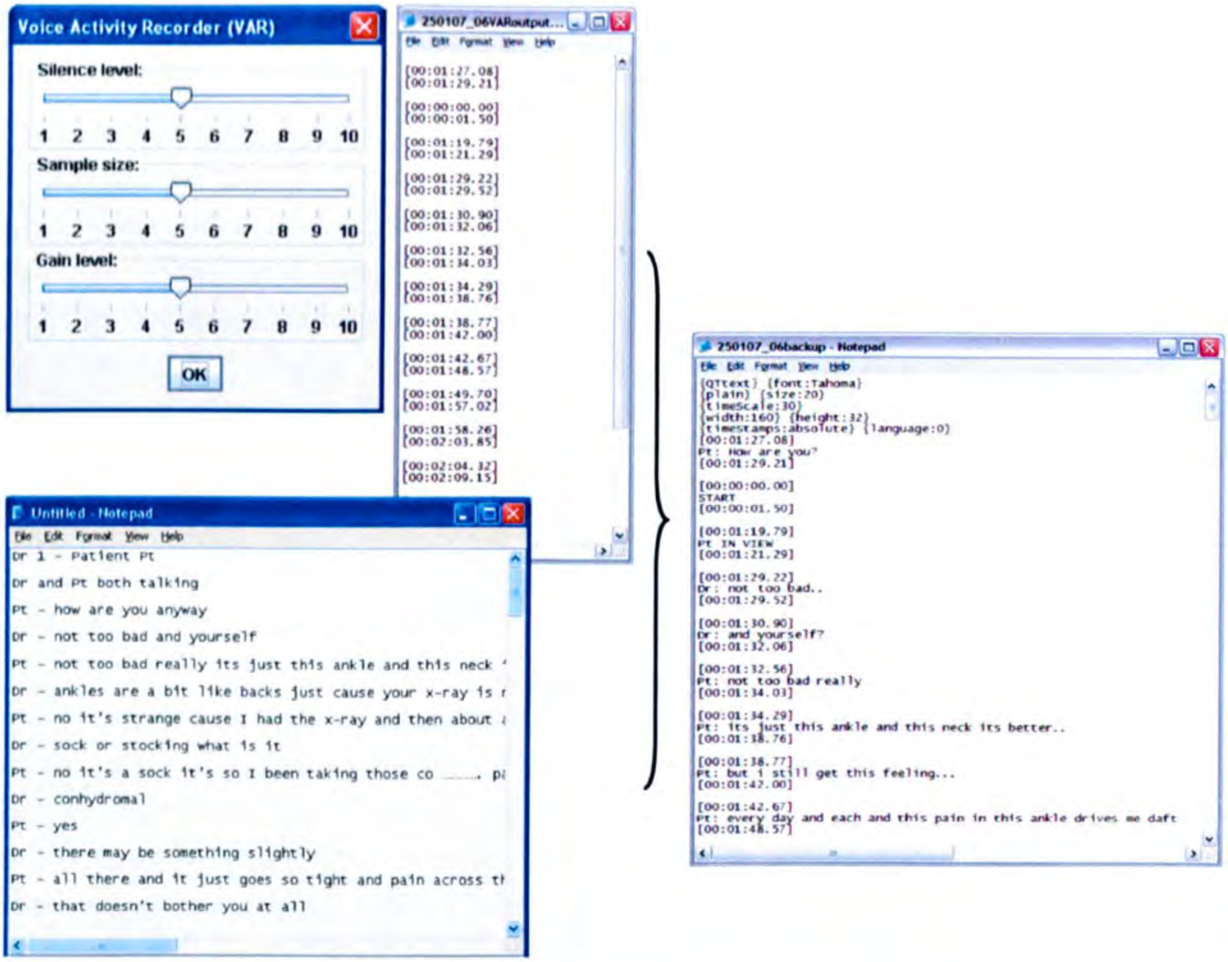


Figure 4.15: Interface and time structured transcripts that could be created using the VAR tool

4.8.3 Investigations into automated capturing of non-verbal interactions

The capacity to interpret non-verbal interactions automatically can improve the data collection efficiency. All non-verbal interactions are of 'continuous' type; they are time consuming to codify and recognising them is subjective.

Previously piloted pattern recognition approach utilised a standard web camera attached to a dedicated computer to analyse patterns of pixel changes. Such techniques allow researchers to define boundary lines around the doctor or patient, define target areas to detect movements – called 'frame rectangles' or virtual lines to identify movements across them. These approaches in general can detect the changes in image pixels based on their cluster sizes, speed, colour values and centre of gravity.

Experiments with frame rectangles placed over the doctor's and patient's head and over the keyboard proved the possibility to recognise movements in those areas. These observations could also be recorded into a log file with timestamps. However, it was difficult to standardise the measurements and to define threshold values to define meaningful movements. Furthermore, the additional efforts for setting them in the consultation room, the influence of the background lighting and the difficulty to use in longer recording sessions hindered the selection of this technique.

Figure 4.16: Use of patter recognition software to detect the movements within marked areas of a video files

	A	B	C	D	E	F	G
1	Time Stamp	Frame	Parameter	Parameter	Parameter	Parameter	Log
2	Milliseconds	Rectangle	One	Two	Three	Four	Interval
3	1000	0	9	200	11	3	1000
4	1000	2	101	333	420	5	1000
5	1000	3	241	535	387	8	1000
6	2001	3	5	67	8	1	1000
7	4003	0	19	201	25	3	1000
8	4003	2	3	67	12	1	1000
9	4003	3	297	334	482	5	1000
10	5003	0	303	800	412	12	1000
11	5003	2	160	334	667	5	1000
12	5003	3	1377	1000	2231	15	1000
13	6004	0	58	467	76	7	1000
14	6004	2	333	801	1395	12	1000
15	6004	3	1037	1001	1679	15	1000
16	7005	2	14	134	58	2	1000
17	7005	3	169	334	272	5	1000

Figure 4.17: The activity log file created by the pattern recognition software indicating the changes of image parameters within the 'frame rectangles'.

Similarly, the author also explored the possibility of automatically measuring the durations for which the doctor is looking at the computer screen. There are number of commercial products that are capable of recording the direction of gaze, and even capable of detecting the precise area of the screen the user is interacting with. However, the majority have hardware components that need to be worn by the computer user or placed in front of the computer screen. They are intrusive to deploy in real consultations.

4.9 The Log File Aggregation (LFA) tool

LFA application was developed as a tool capable of accepting any number of time-structured log files and merging them into a single navigable output. It enables isolation and reviewing of doctor-computer-patient interactions from diverse data collection sources. The LFA application's interface is designed to guide users through its step-by-step process. These steps are; (1) *settings*; configuring the aggregation parameters, (2.) *conversion*: specifying the files for converting, (3.) *aggregation*: combining the log files, (4) *display*: presenting the merged results (5) *output*: exporting of combined output for additional use. Number of log-files LFA can process is limited only by the amount of display area available for the aggregated output.

Currently the LFA tool can accept ObsWin, UAR (User Activity Recording), VAR (Voice Activity Recording), XML and PRS (Pattern Recognition Software) data files. It is written using the Java language, and can be easily customised to handle time structured file of different formats. LFA uses the Java XML package to convert the aggregated output into XML format. It can also produce the output as a comma separated text file (.CSV format) which can be directly imported into most statistical packages and variety of other data processing applications.

The final combined output of LFA represents data from multiple data files, some of which could be from diverse sources. The LFA application produces the aggregated results in three different formats to support further analysis;

- **Tabular data** – A single data table consisting of interactions generated by disparate observational tools. Each row of data represents an observation, detailing the start and end time of an interaction, its type and the source. They are arranged sequentially representing the consultation's duration.
- **Bar charts** – Represents the total durations or frequencies for each of the interaction variables.
- **Occurrence graph** – This is an interactive implementation of the output specification discussed previsouly. Occurrence of each interaction is represented by a rectangle, with its height proportionate to the interaction duration. These *occurrence rectangle* are interactive, clicking on a rectangle plays the corresponding segment of the multi-channel video. They are arranged vertically, each column represents all occurrences for an interaction variable.

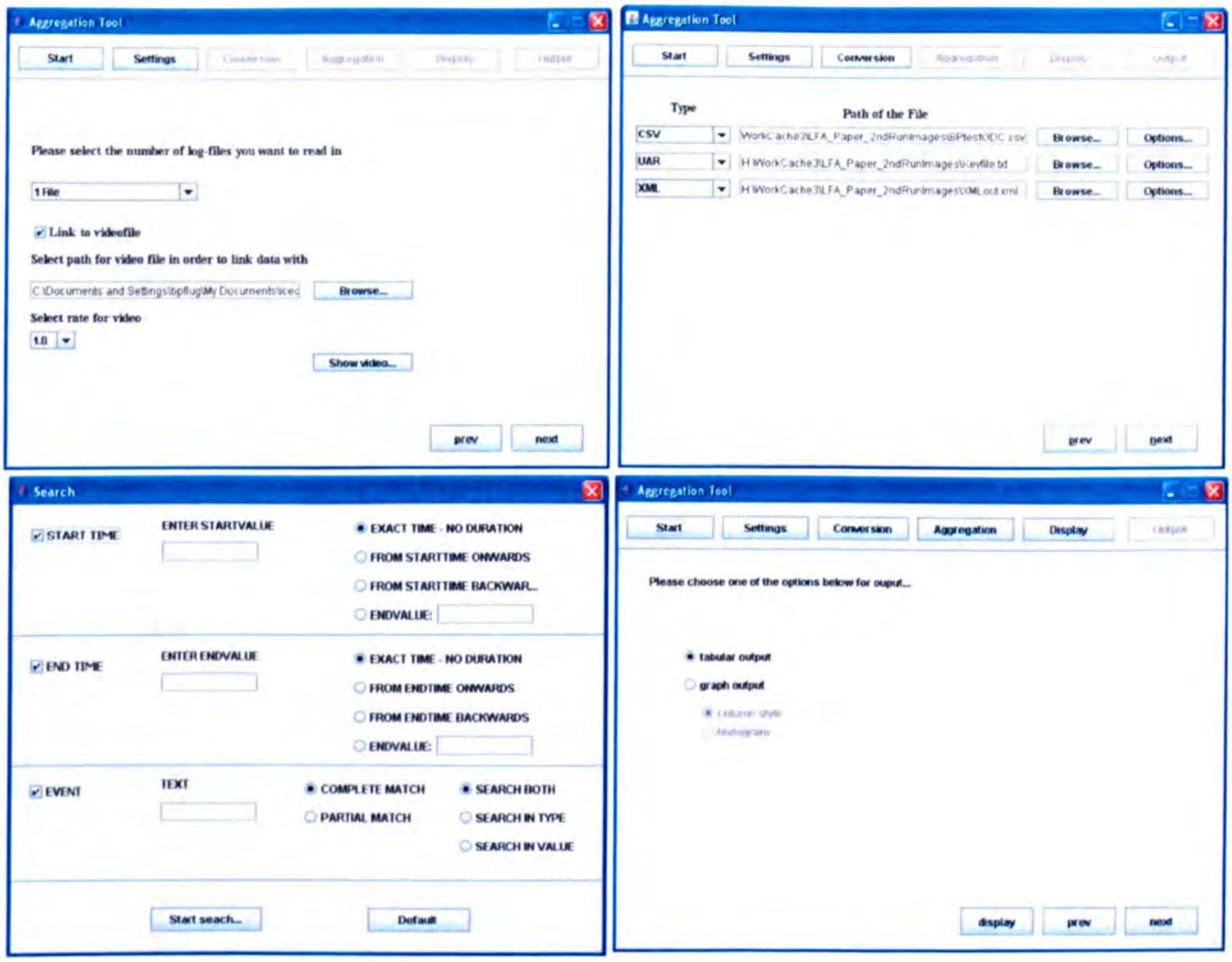


Figure 4.18: Interfaces of the Log File Aggregation (LFA) application – *Settings* page to set the project parameters (top left), *Conversion* page to select the files to combine (top right), *Search* interface to filter observations of interest, *Display* page to view the tabular or graphical outputs

4.9.1 Research advantages of the LFA application

The LFA application not only enables the merging of observational datasets from different sources, it also offers facilities to productively use those for research. It supports defining and deriving new research datasets and allows manipulation of the data presentation to answer new research questions. Following are some of the research advantages LFA tool offers;

- **Removes the risk of human errors** – Combining interaction log-files with different formats manually could introduce processing errors. It is particularly difficult to review and merge interactions with large number of occurrences with short durations. Time conversions and ordering them are also error prone.
- **Direct interpretation of interactions through interactive outputs** – Interactive features of the occurrence graph's rectangles and the data rows of the tabular output enable researchers to understand the purpose of the interaction directly. Furthermore, moving the mouse over an occurrence rectangle or a pillar in the bar chart displays the associated value.
- **Searching and filtering of interactions** – LFA's search facility enables the isolation of interactions of interest based on their type or time constraints. For example, interactions that occurred within the first minute of the consultation or a subset containing only computer use interactions can be directly derived.

Bar chart showing the durations (top) and frequencies (bottom)

Occurrence graph output of the aggregated observations

Tabular output with aggregated observations

Figure 4.19: Analysis outputs generated by the LFA application

- **Generation of new outputs by combining filtered results** - Data sets drawn out from the aggregated output through the search and filter functions can be combined to create new research data sets. They have the potential to supply results focusing on new aspects of the interactions; for example combining the doctor-patient eye contact with coded data entry to assess the influence of the latter on the non-verbal interactions
- **Supports new analysis** – LFA's capacity to generate new datasets from the aggregated output and directly view the particular segment of the video mean the results could be explored to assess their utility for new research designs.
- **Addition and removal of interaction variables in run-time** – Columns in the concurrence graph could be removed and re-introduce dynamically, a feature useful to visually compare relationships between different interactions.
- **Facilities to change display settings** – LFA's graphical outputs have display settings that can be altered directly, increasing their usability.

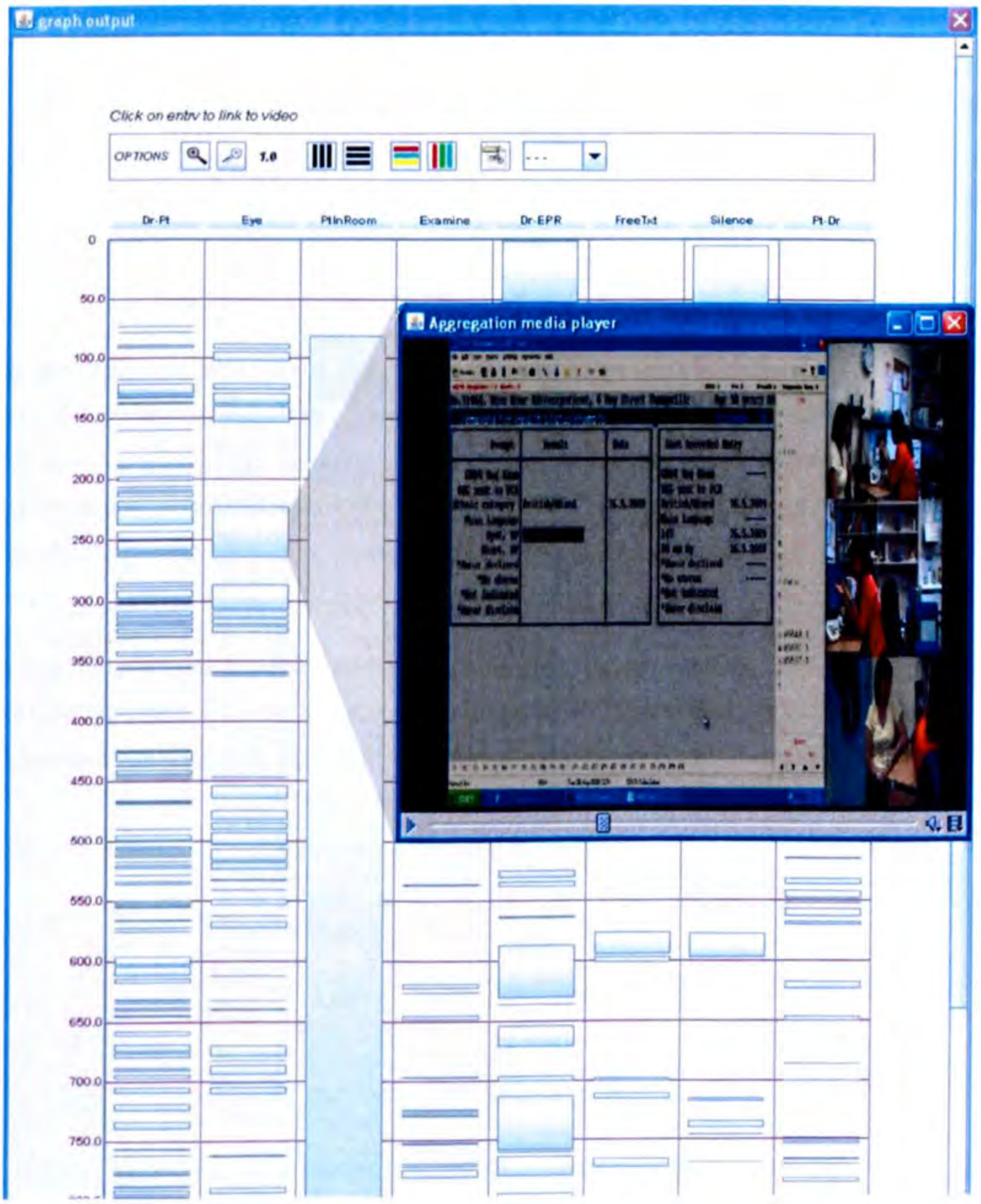


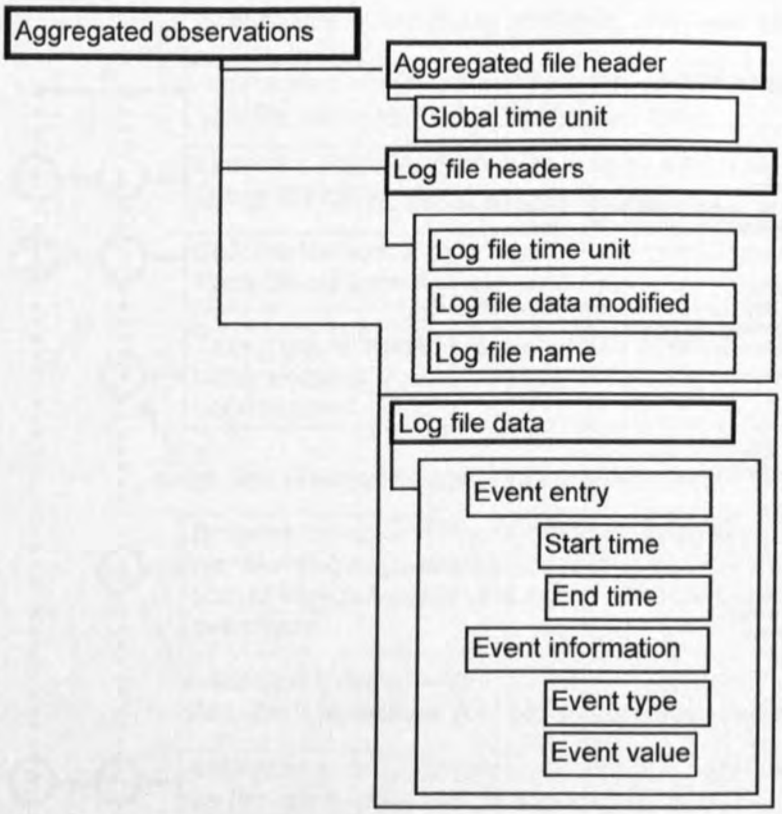
Figure 4.20: The occurrence graph output with video player– clicking on an interaction occurrence plays the corresponding segment of the video

- **Error detection and reporting** – Aggregation process reports any errors in the log-files with specific details. This is useful to verify the accuracy of the observational data and to do validation.
- **Efficiency gains** – Before the introduction of the LFA application, log files were largely processed in isolation. Manual aggregation takes approximately three hours, to combine three different log files from a fifteen minute consultation.
- **Exporting as images** – Graphical representations of aggregated outputs can be exported as images (JPEG format). This facilitates the comparison of observations from the different consultations visually and to share or store them as image libraries.
- **Aggregating data from new disparate observational tools** – The modular design of the application means it can be modified easily to support time-structured data files from new observational tools.
- **Increases the effectiveness of analysing the influence of computer** – The capacity to manipulate the aggregated outputs, their visual representations and linkage with the video file enable the isolation of the computer-use related interactions. They can be then compared with interactions of other types to review the precise nature of the computer use and its influence on the doctor-patient interactions.

4.10 The Extensible Markup Language (XML) schema for the output specification

LFA tool is capable of generating a XML data file representing the aggregated observational data set. This feature enables the production of an analysable description of a consultation by using only a multi-channel video and a XML document in contrast to dealing with multiple data files. Extensible Markup Language (XML) allows the creation of structured electronic documents by encoding of information. It facilitates wider use of information with increased usability and generality. There are number of applications capable of interpreting XML documents.

An XML schema denote the structure of an XML document. It details the data model and the syntax used for a specific XML document. The aggregated output of the LFA tool contains data elements from diverse sources. Therefore its XML schema is designed to have details about the source of observation surrounding the individual time-structured data elements.




```
<?xml version="1.0"?>
<xs:schema>
<xs:element name="Headerinformation">
<xs:element name="GLOBAL_TIMEUNIT" type="xs:decimal" maxOccurs="1"
use="required"/>
<xs: element name="HeaderEntry">
        <xs:complexType>
        <xs:sequence>
        <xs:element name="time_unit" type="xs:decimal"/>
        <xs:element name="last_modified" type="xs:date"/>
        <xs:element name="file_name" type="xs:string"/>
        </xs:sequence>
         </xs:complexType>
</xs:element>
<xs: element name="LogFile" type = "EvenEntry">
<xs: complexType name="EvenEntry">
        <xs:sequence>
        <xs:element name="start_time" type="xs:decimal"/>
        <xs:element name=" end_time " type="xs:decimal"/>
        <xs: element name="EventInfo">
                <xs:complexType>
                <xs:sequence maxOccurs="1">
                <xs:element name="type" type="xs:string"/>
                <xs:element name=" value " type="xs:string"/>
                </xs:sequence>
                </xs:complexType>
        </xs:element>
        </xs:sequence>
 </xs:complexType>
</xs:schema>
```

Figure 4.21: XML schema and the specification for aggregated time structured output

```
<?xml version="1.0" encoding="UTF-8" ?>
- <AggregationTool>
  - <Headerinformation>
      <GLOBAL_TIMEUNIT>1.0</GLOBAL_TIMEUNIT>
    </Headerinformation>
  - <DataEntries>
    - <HeaderEntries>
      - <HeaderEntry>
          <time_unit>1.0</time_unit>
          <last_modified>Thu Apr 12 21:36:10 BST 2007</last_modified>
          <file_name>BPtestObswin250107_06.sds</file_name>
        </HeaderEntry>
      - <HeaderEntry>
          <time_unit>1.0</time_unit>
          <last_modified>Mon Sep 03 13:07:10 BST 2007</last_modified>
          <file_name>BPtestUAR251007_06.txt</file_name>
        </HeaderEntry>
      </HeaderEntries>
    + <UAR>
    - <OBSWIN>
      - <EventEntry>
          <start_time>1.4</start_time>
          <end_time>54.1</end_time>
        - <EventInfo>
            <type>OBSWIN</type>
            <value>X</value>
          </EventInfo>
        </EventEntry>
      - <EventEntry>
          <start_time>5.8</start_time>
          <end_time>60.5</end_time>
        - <EventInfo>
```


Figure 4.22: An XML output generated by the LFA application

4.11 Processing of time-structured data

The aggregated output from the LFA application or the ODC's time-structured data can be directly used for quantitative analysis. Both approaches have been utilised to obtain the outcome measures of this research. Comparisons of consultation task durations have also been performed both at the individual consultation level and the task level across the entire sample. The former requires the processing of the aggregated data to derive a '*one line per consultation*' format, whereas the latter needs a '*one line per task occurrence*' format.

The initial task of this process involved the generation of a *consultation profile* table. Each case in this table represents various characteristics of individual consultation. This table details the session details, the type of EPR system used and doctor's and patient's characteristics. It also contains various measurements of consultation durations that are important for deciding the time available for common consultation tasks or doctor-patient-computer interactions; such as duration of the consultation, interruptions, patient in the room, doctor not in room.

The process of converting the aggregated outputs into the aforementioned two formats is achieved using a stepwise process (Figure 4.23). The author completed this process using the statistical analysis software PASW - version 17, supported by a separate Java programme created for this purpose.

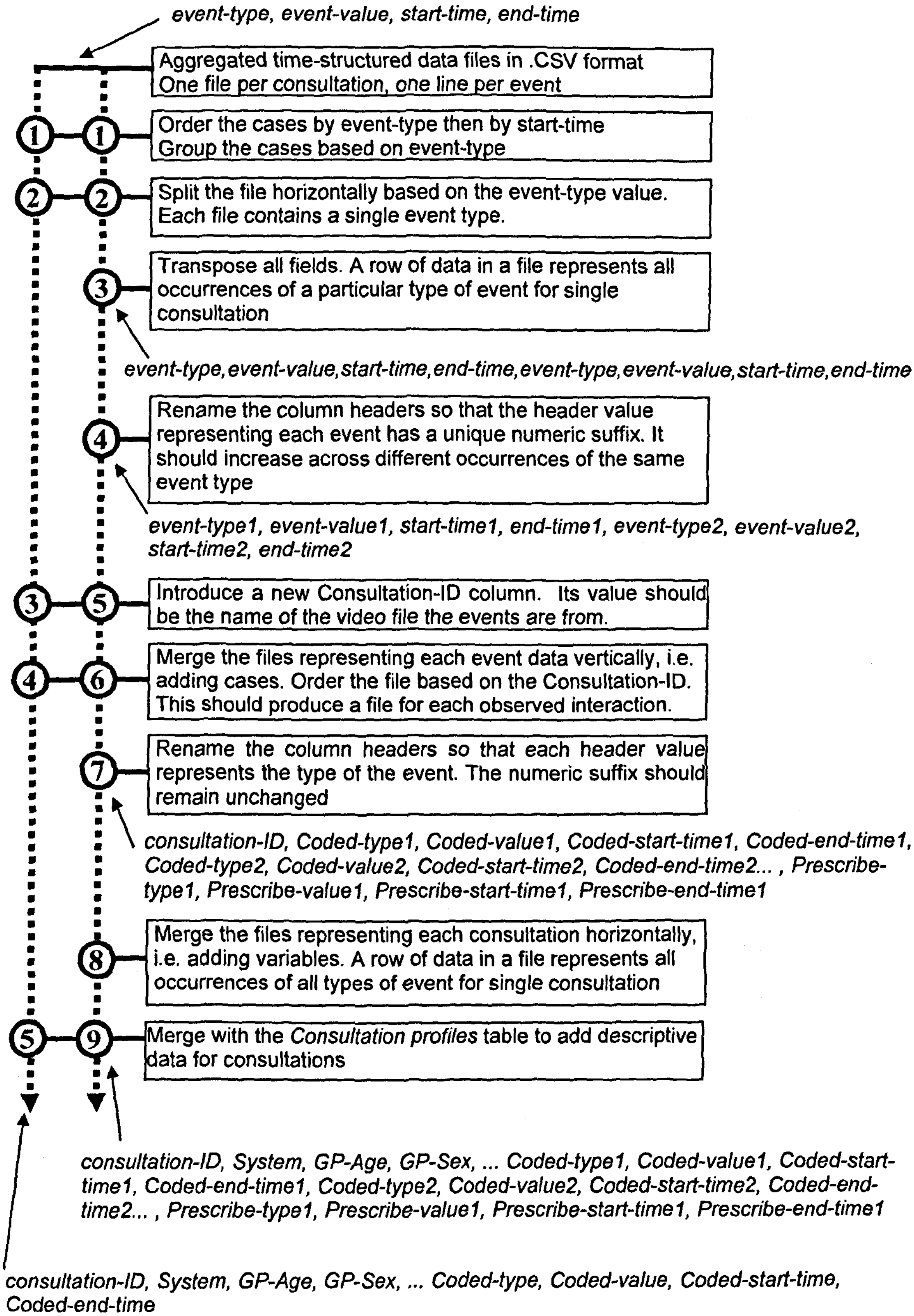


Figure 4.23: Generation of a single file per event type. Each file contains observations from all the consultations in the sample, providing the specific event has occurred.

4.12 Reliability - validation through inter-rater reliability

Inter-rater reliability refers to the agreement, or concordance of agreement among raters. It gives a score which is called intraclass correlation coefficient (ICC). It is a form of validation to show that 2 or more tests give the same results, this is to confirm the repeatability of the experiments. The reliability of coding video recorded consultations has been evaluated in a study the author participated in, which was conducted by Moulene et. Al. (2007). This involved the use of four simulated consultations with three EPR systems; EMIS LV, EMIS PCS and IPS Vision. Consultations were conducted by three experienced GPs, all with over 15 years experience and, one trainee GP. The patients were simulated by members of the research staff. Initially, a series of consultation were recorded to allow the GPs to become familiar with the recording set up. Each clinician was presented with the same simulated patient for a review of their hypertension; their past history was identically loaded in each computer system. Six volunteer undergraduate students, a foundation year medical doctor and the author rated all four consultations. At the time of this research, the ODC application was not developed, therefore ratings were done using the Obswin software. The raters were trained using an instruction manual with screen shots of EPR interfaces and using a training video. The ICC was calculated using the SPSS version 14.0. Its results are shown in table 4.5.

Consultation characteristic	Key	EMIS PCS		EMIS LV (1)		EMIS LV (2)		IPS Vision		Summary	
		Time	%	Time	%	Time	%	Time	%	Median	IQR
General observations											
Duration		6:55		11:26		10:10		8:36		9:13	
Coded entries		0		5		7		4		4.5	
Time/ code		0		0:19		0:18		0:19		0:19	
First view: ***Interaction between actors (C+V = total verbal communication)***											
Computer-Dr	Z	0:03	0	0:06	0	0:11	0	0:05	0	0:06	0:03
Dr-computer	X	0:51	12	2:42	24	4:04	40	2:24	28	2:30	1:03
Dr-Patient	C	3:19	47	3:36	32	6:18	61	3:36	41	3:36	0:39
Patient-Dr	V	2:35	37	4:30	40	2:48	27	2:24	29	2:42	0:36
Second view: ***Data entry times (S +D = Total coding time)***											
Coding	S	0	0	0	0	0:49	10	0:11	2	0:30	0:19
QOF-code	D	0	0	1:36	14	1:18	13	1:06	13	1:18	0:18
Free-text	F	0	0	1:06	9	0:19	3	0:41	8	0:41	0:23
Prescribing	G	0:48	11	0	0	0:54	8	0:36	7	0:48	0:05
Third view: ***Body language in consultation (Q+T), Examination (E) and computer interference (W+R)***											
Eye contact	Q	4:18	61	6:00	53	4:30	43	3:12	37	4:24	0:54
Dr-Comp&speak	W	0:29	7	0:17	2	2:18	22	0:46	9	0:38	0:40
Examination	E	1:12	17	1:42	15	0:58	9	1:36	19	1:24	0:30
Silent time	T	1:08	16	2:00	17	0:29	4	0:58	11	1:00	0:27
Pt-Dr&Comp	R	0:03	0	0:18	2	0:43	7	0:38	7	0:28	0:26
Reliability test: ***Intraclass correlation coefficient (ICC)***											
ICC Value		0.962		0.926		0.931		0.896			
95% CI		0.895 – 0.991		0.833- 0.978		0.854 – 0.977		0.783 – 0.962			

Table 4.5 – Comparison of reliability test results from four simulated consultations
(interaction variable; Z = Computer-doctor interaction; X = Doctor-computer; C = Doctor-patient; V= Patient-doctor interaction; S = Coding; D = Quality target coding; F = Free-text entry time; G = Prescribing time using the computer; Q= Eye contact W = Doctor using computer and speaking; R = Patient speaking to doctor, while doctor uses computer)

The four hypertension monitoring consultations took between 7 and 11 minutes. The reported reliability values were satisfactory. The intra-class correlation coefficient of the consultations ranged from 0.962 (95% CI 0.895-0.991) to 0.896 (95% CI 0.854 – 0.977). These estimates suggest that this method has a high inter-rater reliability. Doctor-patient interactions were recorded more accurately by the rates compared to the doctor-computer interactions. Feedback from the raters indicated the need for additional training to understand the purpose of EPR interface features and for having clear definition for the start and end of the interactions under investigation.

4.13 Summary

This chapter detailed the technical developments associated with the research method of this study. In the absence of any suitable off the shelf application, a development process has been introduced to produce a set of applications (figure 4.24) which would enable researchers to capture the complexity of the computer mediated consultation. First the existing multi-channel video recording approaches were compared to recognise the most comprehensive method. Discussions in this chapter also presented the effort taken to identify low cost methods of filming the consultation, ideally using unobtrusive tools, which recorded sound and video with a digital time signal so that precise synchronisation was possible. A new set of enhancements have been introduced to the video recording elements to support extended recording time and to minimise the time taken to produce a multi-channel video.

A supplementary set of software tools have been introduced to automate the data capturing process where possible. These new tools were developed based on the findings from the previous chapter and also to support the demands associated with the research hypotheses. A new application (Observational Data Capture – ODC) has been introduced to enable the coding of consultation interactions in the video output. Another tool, the 'User Action Recording' (UAR) application can measure the precise time-stamp of key board use (each key depression is recorded and time stamped) as well as all mouse clicks and coordinates. The 'Voice Activity Recorder' (VAR) tool has been developed to detect and time stamp the start and end of speech.

A new data processing tool; the Log File Aggregation (LFA) has been introduced to aggregate the output from multiple data collection systems into a single data file which would be readily navigable. The LFA tool combines any number of time stamped log files of different formats. The data imported into LFA can be viewed as histograms or occurrence graphs, and enables researchers to review a specific spot in the multichannel video by interacting with an interaction variable. This enables users to navigate into any section in the consultation they wish to study and simultaneously view all the log files relating to that point in time. This also creates a single exportable file in the XML format which can be used to develop UML Sequence diagrams.

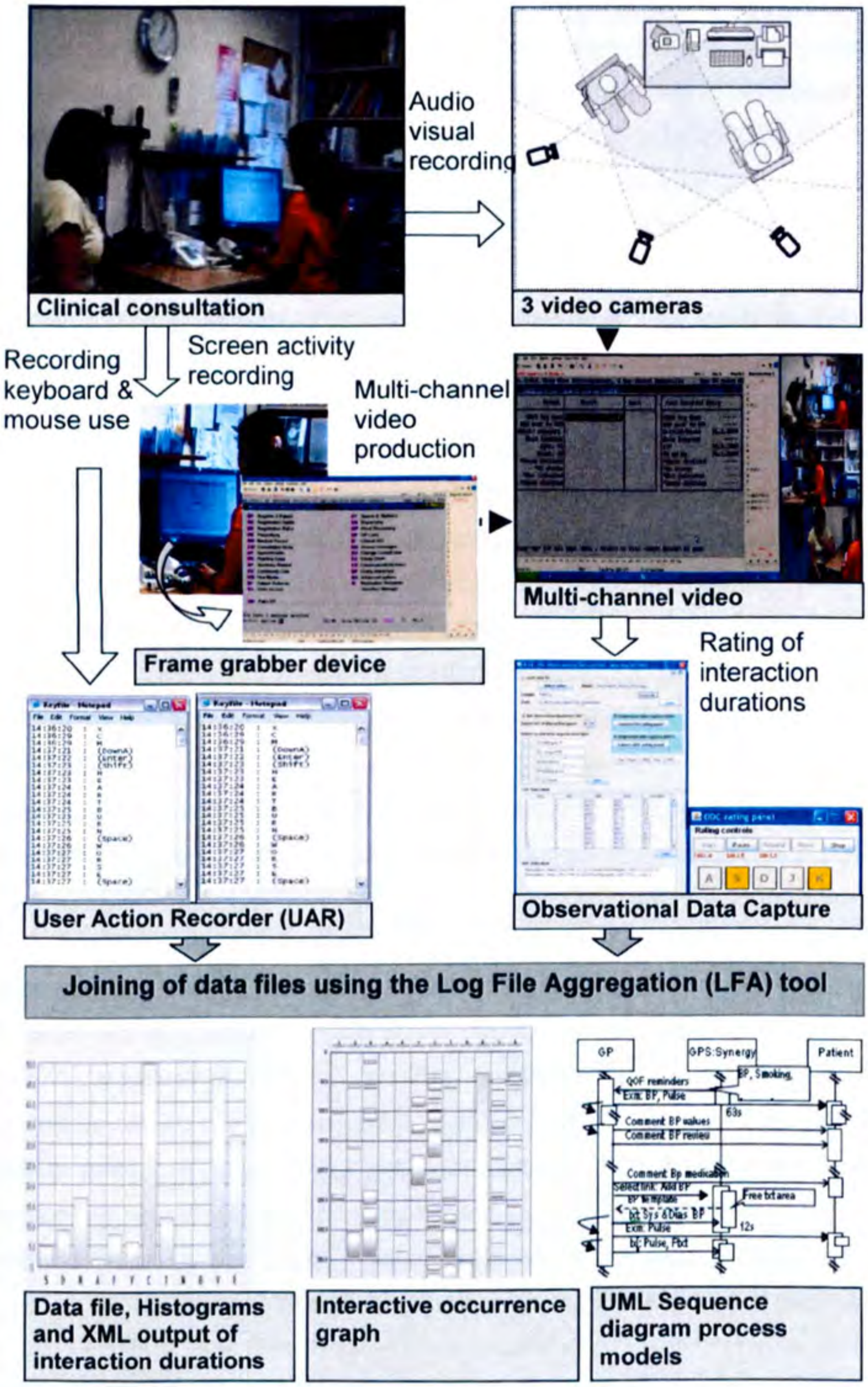


Figure 4.24: Summary of the technical method

CHAPTER 5
Analytical method and data collection

5.1 Introduction

Generation of process models involves application of a suitable modelling technique on to a selected system perspective. A process model represents the information, activities and behaviours of a system using an easily interpretable graphical notation. Over the time, the frameworks for adopting these modelling concepts have evolved and are standardised to be compatible with non-software development objectives. This section initially evaluates the existing commonly used process modelling approaches based on the needs associated with consultation analysis research. A process modelling specification customised to represent the doctor-patient-interaction, with emphasis on reporting the influence of computer use is presented subsequently.

This chapter primarily attempts to develop and enhance the analysis frameworks needed to validate hypotheses Hs7 and Hs8. Previous chapter discussed the development of the technical apparatus. This chapter presents the enhancement to the research design by strengthening the approach adopted to interpret the consultation observation outcomes. This meets the demands associated with the last two research hypotheses by providing a systematic framework and theoretical justification for the chosen research strategy. First it details the video rating process, accompanied by an introduction to the interaction categories used for the detailed analysis. The definitions of each consultation interactions measured in this study are presented in the appendix B. This chapter establishes how precise interaction descriptors support precise measurement of interaction durations, and collection of data about useful contextual information. They are crucial in assessing the findings linked to hypotheses Hs4 and Hs5, where precise influence of computer use is the focus.

Furthermore, this chapter also presents a framework developed to categorise different sections of the consultation length, considering the pragmatic elements of the consultation workflow to support distinguishing of possible patterns of interactions. This study also adapted a classification of consultation room layout to explore its influence on the consultation tasks. Concepts pertaining to the consultations contexts, the data collection approaches and analytical method adopted in this research are eventually developed in to comprehensive reference framework, and is described in the last chapter of this research.

5.2 Developing the process modelling approach

The author evaluated three commonly used process modelling techniques (Table 5.1) to ascertain their suitability to represent a consultation workflow; Integrated definition for function model (IDEF0) (Badica C et al, n.d.), Data Flow Diagrams (DFD) (Donald S, 2000), and Unified Modelling Language (UML) (Rumbaugh et al, 2004).

UML notation has been selected as the modelling approach to abstract consultation processes. As discussed in the literature review, it has been previously used for representing health care workflows. It also provides a number of diagram types to abstract deferent system prospects. However, there is a risk of the selected modelling approach becoming incapable of representing the aspects which are of interest, and to a useful level of detail. UML meets this challenge by introducing extension mechanisms; means for customising the basic UML notation to meet specific needs of the intended application. In contrast, though used in a wide range of contexts there are no reported studies on the use of DFD and IDEF for interaction focused process evaluations in healthcare setting.

	Integrated definition for function model (IDEF0)	**Data Flow Diagram (DFD)**	**Unified Modelling Language 2.2 (UML)**
Introduction/Key concepts	→ A functional model that graphically represents business processes to any level of details through their activities, their interdependencies and controls. →It is a structured system design techniques adopting 'Process driven decomposition'. →Processes are visualized with their associated inputs, controls, outputs and mechanisms. (ICOM)	→Represents the flow of data among external entities and through the internal business processes. →Can be developed either to give more prominence to the physical aspects (Physical DFD) or to the conceptual aspect (Logical DFD). →It is a structured system design techniques adopting 'data driven decomposition'.	→A general purpose modelling language for specifying, visualizing, constructing and documenting the artifacts of a system. →UML model is a graphical combination of 'things' and 'relationships'. It introduces 14 different kinds of diagrams to represent different aspects of a system. →Capable of representing both the structural and behavioural aspects
Pros	→Comprehensively represent s variety of processes to any level of details. →Promotes consistency of usage while maintaining a high precision of expression. →Simple and promotes hierarchical decomposition of activities. →Processes can be decomposed into detail levels until the model is fit enough for the modelling objectives.	→It gives more emphasize to visualize the flow of data within the system throughout its origin, manipulation, transformation and storage. →More specific details about the flow of information can be presented by different levels of layers.	→Promotes the development of precise, unambiguous and complete process models. →Provides set of notations to abstract structural, behavioural and physical aspects of systems. →Can be intuitively interpreted by users with less familiarity about the system or less technical knowledge. →Extensions are available for non standard modelling issues.
Cons	→Gives little attention to the logical organization of the data. →The model could become too concise to be interpreted by users who have little knowledge about the system. →Can not effectively represent parallel, conditional, iteration and selection of execution paths.	→Does not represent the control information with the details of the timing or the order of the process execution. Event flow can not be directly interpreted. →Represents the structure based on the transformation of data rather than the actual processes. →Does not show sufficient information about the aspect of description. Can result in multiple interpretations.	→Encourages an object connection architecture rather than interface connection architecture. →Difficult to perform a rigorous semantic analysis due to lack of precision.

Table 5.1: Comparison of widely used process modelling approaches

5.2.1 Selection of UML as the process modelling approach

Interactions are central in defining the behavioural aspect of the consultation. We have previously established time as an influential determinant for the consultation process and for the outcomes. Ability to evaluate consultation interactions contextualised by the consultation's progress along its time line is constructive. The way in which each participant takes part in the interactions by either initiating in or responding to tasks defines the consultation workflow. UML Sequence Diagrams have the potential to support those requirements. This decision was further justified by an allied research study the author conducted to assess the capacity of the UML notation to support process modelling in non-software environments, and the suitability of the behavioural diagrams to provide a process evaluation framework (Kumarapeli et al, 2007a).

Furthermore, with the view of exploring system design strategies that could support the computer to integrate well with the consultation, the analytical approach of this study adopts the notion of goal driven interactions as mentioned below in section 5.2.2. Selection of the UML sequence diagrams as the process modelling technique, and its specification described below has the capacity to corroborate this interaction oriented approach.

The latest UML notation (version 2.2), provides 14 different diagram types. They are broadly categorised as Structure and Behaviour diagrams, capable of representing static structural or dynamic behavioural information respectively. Behaviour diagrams (Figure 5.1) have the potential to represent active and interactional characteristics of the consultation. Table 5.2 summarises the feature relevant to the consultation interactions present in the seven types of UML's Behaviour diagrams.

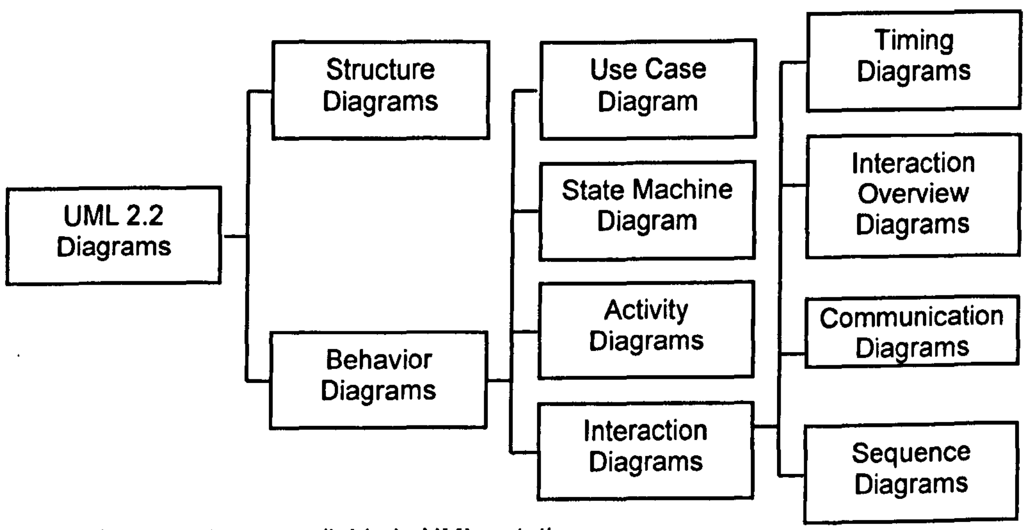


Figure 5.1: Diagram types available in UML notation

Diagram	Characteristics of the abstraction
Use case diagrams	• Represents user and system interactions • Defines constraints, behaviours and system requirements • Based on scenarios
State Machine diagram	• Presents the instant to instant condition of a single object– the 'run state • Sequence events linked to an object through its life time
Activity Diagram	• Contains activity states and action states, transition of data between activities; Sequential, branching, joining transitions. • Parameters of the operation and associated objects can be shown
Communication diagrams	• Represents sequence of messages between objects at run-time • Association between objects
Timing diagram	• Displays state of the object over time and the messages that influence them • Combination of State and Sequence diagrams
Interaction overview diagram	• Combination of Activity and Sequence diagrams • Represents the interaction occurrences and interaction elements
Sequence diagram	• Represents Interactions and their time ordering • Shows associations and interactions among the objects that send and receive information • Represents the different elements that work together

Table 5.2: Characteristics of UML's diagram types suitable for modelling system behaviours

5.2.2 Actor-actor interactions in a consultation

When the relationship with actors and system is concerned, the Use Case approach often recommends considering the system as a 'black box'. Then to analyse the interactions actors perform with the system. It further considers the responses received from the system as activities happening in the outside.

Fundamentally, a Use Case depicts the 'Who-What-Why' features of the systems, i.e. how Actors (who) interact (what) with the system to achieve a particular goal (why). Though the Use Case specification in the UML2 approach does not formally acknowledge the interactions between actors, this rule is not strictly followed, as the overlapping behaviours amongst them are often represented using generalisation or association type relationships (Glinz M, 2000). Conversely, representation of actor-actor communication as driven by objectives each actor is having to perform certain tasks (Cockburn A, 2001) provides more interaction oriented interpretation of the consultation. This framework has three elements; responsibilities, goals and actions. The actor with a 'goal' would make a 'request' from another, to accomplish its 'responsibility'. The actor entity on the receiving end would make a suitable 'response' in return, corresponding to its own 'responsibility'. It is this connection between the goal and responsibility that requires actors to communicate with each other. At times, a computer could play a direct role in directing the consultation. For example, independent studies in the UK and Australia showed how the computer can define the consultation agenda (Pearce et al, 2010). There is a potential to consider a consultation as a stage where three actors are interacting with each other. Box 5.1 shows instances where responsibility-goal-action framework could be used to interpret doctor-computer interaction.

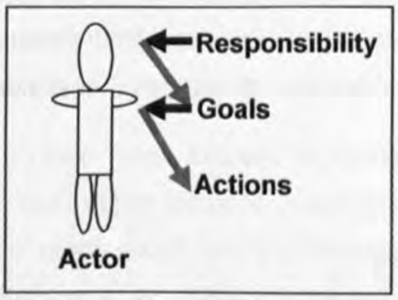


Figure 5.2: Actor and its behaviours

→ The doctor wants to assess the effectiveness of the current anti-hypertensive medication **[clinician's responsibility]**.

→ His plan is to get an overview about the patient's past blood pressure measurements and compare them against the measurement taken during the ongoing consultation **[clinician's goal]**.

→ Since neither the doctor nor the patient could recall all the past BP measurements, to achieve this goal the doctor has to seek the assistance of the EPR system. This is for the reason that the doctor is aware of the capability of the EPR system to store past BP measurements and to present them as a set of ordered values **[EPR's responsibility]**.

→ This doctor-EPR system interaction starts by doctor making a request through the EPR systems interfacing devices **[clinician's action]** to display the past BP measurements related to the currently loaded medical record.

→ EPR system responds to this by displaying a chronologically ordered set of past BP measurements through its screen interface **[EPR's action].**

Box 5.1: Interpretation of doctor-patient-computer interactions based on goal-action framework

5.3 Development of the UML sequence diagram specification

This section focuses on developing the approach for modelling the behavioural aspects of consultation tasks.

5.3.1 Object, messages, time and extensions

UML Sequence diagrams are designed to represent behavioural aspects of system components, giving prominence to the order of interactions between them. *Objects* are the core representative elements when studying behavioural aspects. In UML terms, a *Class* is a generalised representation of *objects* with common properties and responsibilities.

Sequence diagrams represent the interactions between object instances by showing the messages passed between them. There are four types of interactions;

- **Synchronous** - one object sends a message and waits for or expects a reply from the received object
- **Asynchronous** - One way communication form one object to another, without waiting of a reply

- **Creation** – Causes the creation of a new object instance
- **Reply** – A message sent as a respond to an earlier request

The other core concept embedded in the sequence diagram notation is the progression of the time. The time dimension of the objects involved in interactions is shown by a vertical line, enabling comparisons between different threads of communications in relative to the total encounter duration.

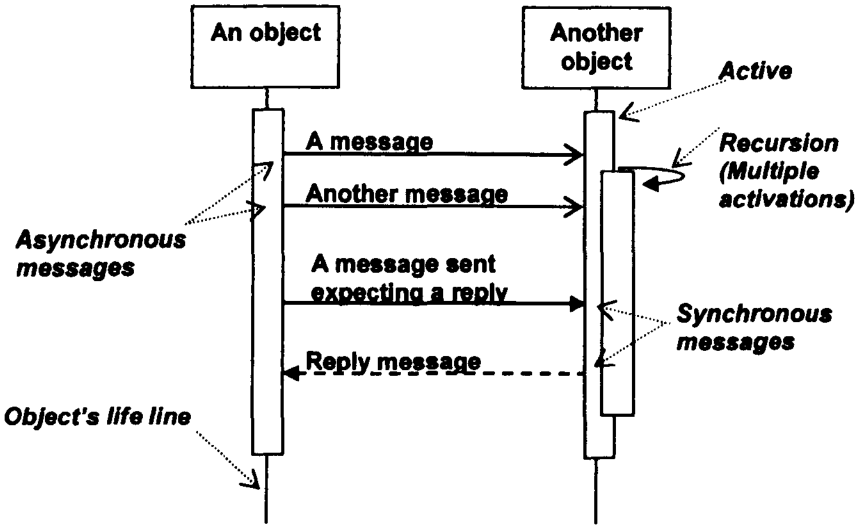


Figure 5.3: Main elements of a Sequence diagram

Uniqueness of the consultation setting warrants the use of extension mechanisms available in UML; not all properties of doctor-patient-computer, that are of important when analysing the influence of the computer can be represented using the standard Sequence diagram notation. There are three possibilities to customise a UML diagram type;

- **Constraints** – extending the semantic boundaries
- **Tagged values** – introducing new modelling attributes
- **Stereotypes** – introducing new elements for modelling

5.3.2 Framework and approach

The initial step for generating a Sequence diagram specification was aimed at identifying the object instances present in a consultation setting. The earlier established notions on the importance of interactions, the influence of doctor-patient relationship, consultation tasks facilitated by the EPR systems, reliance on information and so forth are of importance to this process. Those concepts indicate the involvement of three principle concrete entities for interactions; doctor, patient and computer.

Some consultation models consider doctor, patient and the problem under discussion as the three key components. However, more recent theoretical models the notion of disease largely transpires as a focus for interaction. Approach adopted in this study does not consider *problem* as needing same level focus as for doctor, patient and computer triad. Furthermore, keeping the disease as a separate UML *'thing'* is useful in defining the purposes for interactions. The respective classes of the three chosen object instances (i.e. doctor-patient-computer triad involved in a particular consultation) have unique sets of attributes and responsibilities, defining their characteristics within the context of a consultation. For example, the *'doctor class'* has qualifications as a property and their ability to examine patients, prescribe medications, chronic disease management tasks representing their common behavioural aspects. Both the patient and EPR system have similar sets of unique properties and behaviours.

The next stage focused on recognising the interactions types between doctor, patient and EPR system object instances, compared to the four message types offered by UML. The existence of the *synchronous* and *asynchronous* types of communication has been noticed in the pilot studies (Refsum et al, 2007). Figure 5.4 represents their existence in a computer assisted consultation. Patient not having the ability to interact directly with the EPR system interface features mean only asynchronous messages exist between them and they are always directed from the computer towards the patient. A situation where doctor points out an important piece of information on the screen is an example for this.

Examples for Synchronous messages	Examples for Asynchronous messages
Doctor asks a question related to the family history, and waits for a reply from the patient, if reply was not clear clarifies the question further.	Doctor comments about the examination results or gives dietary advice
Patient asks for a clarification regarding side effects and expects a reply from doctor	Patient comments about work pressure
Doctor enters a text for diagnosis title and waits for the relevant list of Read codes to appear.	Doctor makes a free text entry into the medical record

Table 5.3: Examples for synchronous and Asynchronous messages

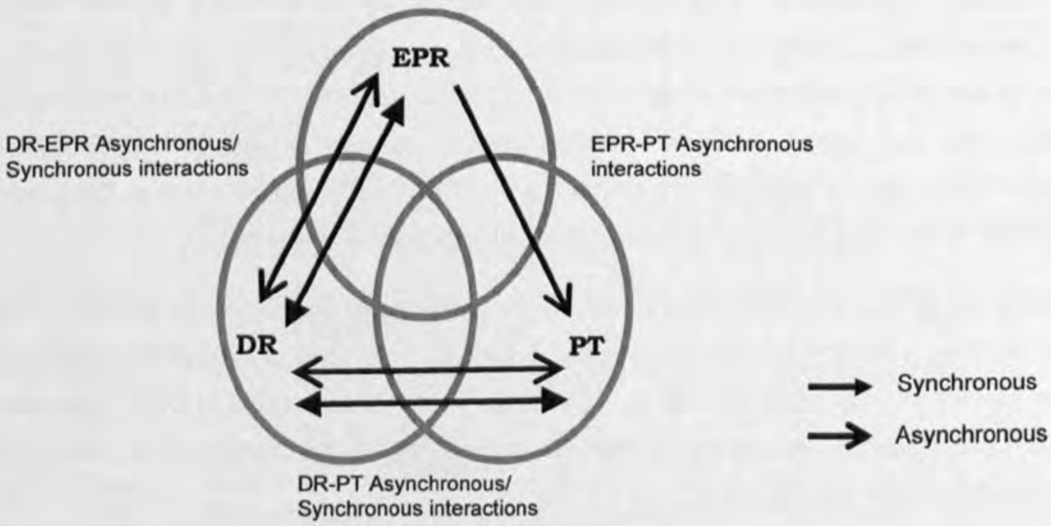


Figure 5.4: Interaction types visible in a consultation

The next stages focused on representing the active or inactive status of the objects and their characteristics with respect to the verbal and non-verbal interactions that take place. The content of different messages, their purposes and end results were also explored. This stage has been largely carried out as an iterative process;

Step A – Representing the interactions corresponding to the common consultation tasks based on the observations from simulated consultations,

Step B – Evaluating them based on their ability to abstract the actual observation without loosing attributes significant to the research domain.

Step C – Introducing extensions to the modelling notation or refine the model to enhance its usefulness and repeat step A.

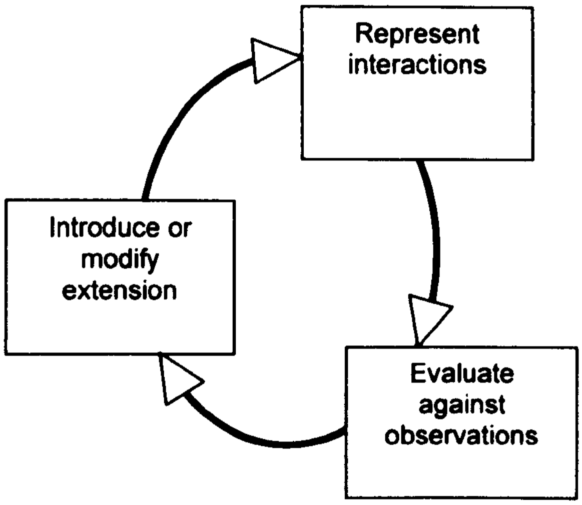


Figure 5.5: Customisation of the Sequence diagram notation to represent consultation interactions

5.4 UML sequence diagram specification for a computer assisted consultation

When representing the consultation, prominence has been given to the order of interactions, instead of providing information about the structural relationship or the exact duration values. However, the interaction occurrence rectangles approximately indicate the duration of the activity in proportion to the total consultation duration. The graphical elements for 'duration constraints', consultation time line, and 'comments' provide specific duration values for interactions of significance. A separate bar chart with data from the ODC segmental log file supplies the precise duration values to identify interactions that need further investigations (Figure 5.7).

To ensure the clarity of presentation, specific details about the visual design are not indicated in the sequence diagram, if needed they can be mapped on as an extra layer of abstraction referring to the screen capture. The notion of 'annotational' things facilitates the displaying of textual comments within the model. They are also useful to indicate process issues, which author has used in an earlier study (kumarapeli et al, 2007).

Content of a message label is important. It details the interaction and is essential to interpret the purpose of the interaction. It also represents the doctor's use of EPRS features in the consultation workflow, and instrumental in assessing their influences.

Activities that involve significantly larger number of interactions are hidden in the main diagram as 'interaction occurrences' and indicated in separate sequence diagrams. This improves the clarity of the abstraction, and provides greater level of insight into the interactions. These have been particularly useful for indicating the common consultation tasks that involve increased amount of computer use.

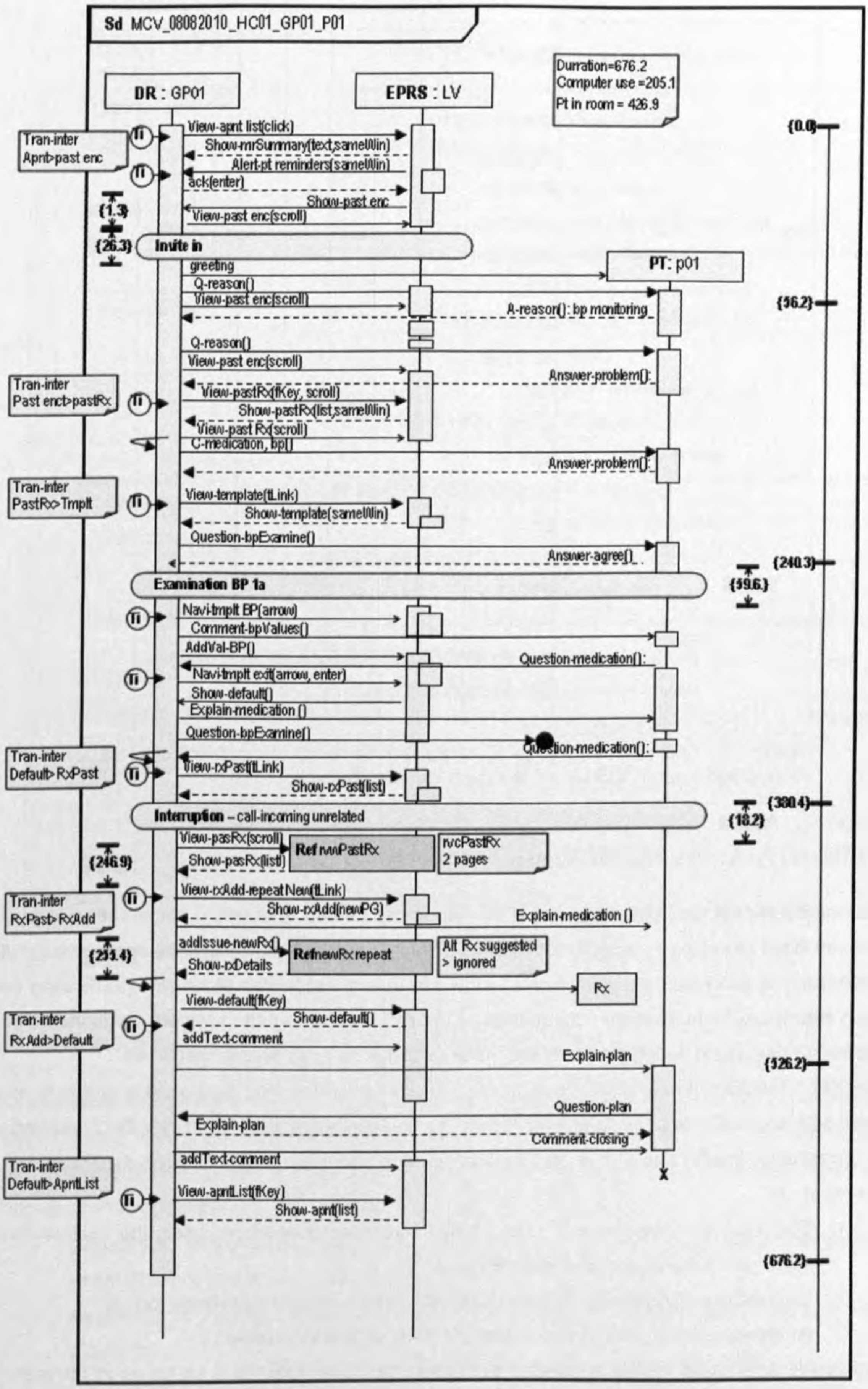
Table 5.4 states the extensions introduced to the UML sequence diagram specification to represent the consultation tasks. Figure 5.6 represents the full sequence diagram of a consultation aimed at Hypertension monitoring. The EPR system used there is EMIS LV. Figure 5.7 details the sequence of computer use interactions with their durations. Analysing the consultation using both those outputs is important when exploring patterns of computer use in a consultation and to compare with other samples.

Sequence diagram element	Description – including extended definitions
Time	Time runs vertically. An additional line in the right of the diagram represents the consultation durations, and to mark various episodes of interest.
Frame	Represents the consultation room.
Heading compartment	Indicates the consultation video file name, for consultation segments this should specify the task name. ***[sd <video file name> [<task name>]***
Objects	Three object instances representing doctor, patient and EPR system. Optional to indicate persons accompanying the patient, depends on the research objectives.
Object life lines	Vertical dashed line. Exist continuously throughout the duration of the consultation for doctor and computer. Patient's line starts from point of entry.
Object creation	New objects for prescriptions and any document printed in the consultation. No life line shown.
External actors	Individuals except doctor, patient and those who accompanied the patient. Placed in the left on the diagram, outside the consultation time line.
Execution occurrence (Focus of control)	Narrow rectangle over the life line. when involved with high level interactions. To indicate interactions within, the following conditions should be met; **(1) Doctor/patient** – participating to verbal interactions; talking or listening, non verbal interactions, **(2) Doctor specific** – physical examination, using the computer and its peripherals, **(3) Patient specific** – being examined, **(4) Computer** – doctor or patient looking at the computer screen, doctor using the computer peripherals. Start/end times as defined for the ODC rating specification. Active objects can initiate interactions without invocations.
Interactions	Shown as messages between *execution occurrence* rectangles. Message label details the interaction.
Direction of message	From sender to receiver, ignores the UML's left to right convention.
Reflexive messages	In EPR lifeline these represent the new functional features triggered over the default consultation mode functions. E.g. use of template, an alert interface, coded data entry popup window. The new activity shown as a separate rectangle over the existing execution occurrence, offsetting slightly to the right. Message should follow the normal convention. When used with the doctor or patient, they represent relationships between interactions – how one interaction directly caused to trigger another interaction
Message syntax	Indicates the type, purpose and content of interactions. Modified from UML syntax; ***<Operation name/goal>[-]descriptor(<arguments>):<values>***. No strict parameter value specification to follow, should be defined based on the research objective. A standard set of parameters values for 'Operation name' and 'arguments' recommended (shown separately). Short and meaningful descriptors.

	Return values optional - recommended for synchronous messages.
Lost/found messages	Shows verbal interactions not acknowledged by the receiving party, or unsuccessful interactions with the EPR system
Iterations	For recursive interactions between doctor and EPRS. Header indicates the purpose of the interaction. Header format: ***loop <task name>***
State.	Represents significant events that influenced the flow of the consultation. Use only for physical examination, interruptions and durations doctor is not in the room
Interaction occurrences	Use when a considerable number of interactions are involved, to place them into a separate *combined fragment. Interaction occurrence* acts as a place holder and should be indicated by the '***ref'*** keyword with a meaningful name. Recommended to represent the common consultation tasks of interest
Parallel interactions	Useful for indicating segments of screen sharing. Using *'Coregion'* notation or including them into a operand compartment with the ***'Par'*** keyword does not provide a clear indication, due to the number of possible interactions. Parallel interactions should be included in a separate *interaction occurrence*, with the heading clearly indicating it has a screen sharing segment.
Annotations	**(1) Comments** – provide detail about any significant observation. A comment in the top right corner presents the duration summary data. Describe the transitioning interactions with the details of the start and end functionalities. **(2) Time constraints** – not used. **(3) Duration constraints** – Represents the duration of interactions that are significant for analysing the consultation process. Should contain a single value indicating the time in seconds. For indicating durations of interruptions, physical examinations, inviting patient in, doctor not in room and transitions. Not used as a constraint.

Table 5.4: Extended Sequence diagram notation for representing consultation interactions

Figure 5.6 (next page): Sequence diagram of a consultation conducted with EMIS LV.



Sd MCV_08082010_HC01_GP01_P01
Durration=676.2
Computer use =205.1
Pt in room = 426.9
DR : GP01
EPRS : LV
PT: p01
Tran-inter Apnt>past enc
View-apnt list(click)
Show-mrSummary(text,sameWin)
Alert-pt reminders(sameWin)
ack(enter)
Show-past enc
View-past enc(scroll)
{1.3}
{26.3}
Invite in
greeting
Q-reason()
View-past enc(scroll)
A-reason(): bp monitoring
Q-reason()
View-past enc(scroll)
Answer-problem()
Tran-inter Past enct>pastRx
View-pastRx(fKey, scroll)
Show-pastRx(list,sameWin)
View-past Rx(scroll)
C-medication, bp()
Answer-problem()
Tran-inter PastRx>Tmplt
View-template(tLink)
Show-template(sameWin)
Question-bpExamine()
Answer-agree()
Examination BP 1a
Navi-tmplt BP(arrow)
Comment-bpValues()
AddVal-BP()
Question-medication()
Navi-tmplt exit(arrow, enter)
Show-default()
Explain-medication ()
Question-bpExamine()
Question-medication()
Tran-inter Default>RxPast
View-rxPast(tLink)
Show-rxPast(list)
Interruption – call-incoming unrelated
View-pasRx(scroll)
Ref rvwPastRx
rvcPastRx 2 pages
Show-pasRx(list)
{246.9}
Tran-inter RxPast>RxAdd
View-rxAdd-repeatNew(tLink)
Show-rxAdd(newPG)
Explain-medication ()
addIssue-newRx()
Ref newRx repeat
Alt Rx suggested > ignored
Show-rxDetails
{255.4}
Rx
Tran-inter RxAdd>Default
View-default(fKey)
Show-default()
addText-comment
Explain-plan
Question-plan
Explain-plan
Comment-closing
Tran-inter Default>ApntList
addText-comment
View-apntList(fKey)
Show-apnt(list)
{0.0}
{56.2}
{240.3}
{59.6}
{380.4}
{18.2}
{526.2}
{676.2}

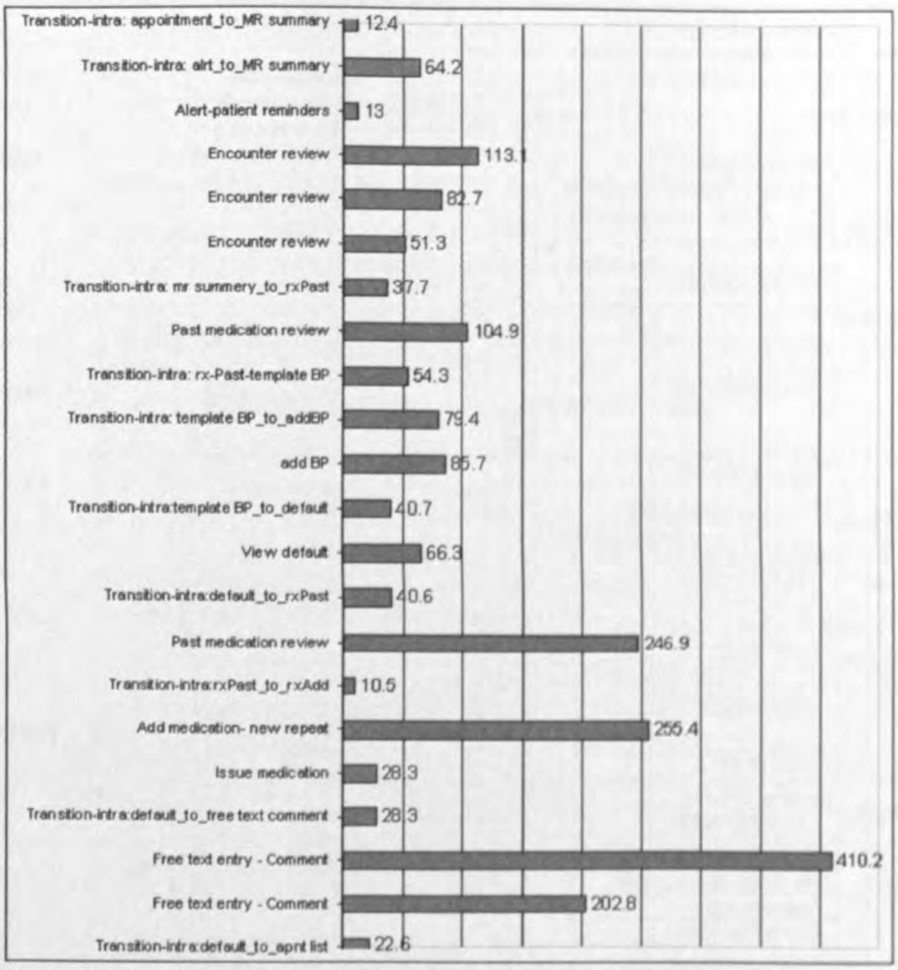


Figure 5.7: Episodic interactions durations representing the computer use in a consultation using EMIS LV (time shown in tenth of second)

5.5 The ALFA (Activity Log File Aggregation) tool-kit

Developments that took place as part of this study contributed to create a comprehensive multi-channel video recording approach, covering all aspects of consultation research; observation, data collection and analysis. This all-inclusive study design and associated technical specification has been introduced to the research community as the ALFA toolkit. All the software components that the author developed during the study are made available as open-source resources.

The ALFA tool-kit represents the developments discussed in this and the previous chapters as a three step approach for consultation analysis. This categorisation aims to simplify the presentation of the research method, and promotes a purpose driven adoption of its components. Three ALFA elements are;

1. **Observation** - Recording of doctor-patient-computer interactions using the multi-channel video, and other observational techniques.
2. **Unification** - Combining multiple observations into a single analysable format
3. **Analysis** - Use of aggregated outputs to study consultation tasks

The ALFA tool-kit was initially introduced to the research community in a workshop at the special topic conference of the European Federation of Medical Informatics (EFMI-STC) in 2008. It was organised by the Open Source specialist group of British Computer Society's Health Informatics forum (BCS-HIF).

	Stage of ALFA method	ALFA technique	Output
1.	**Observation**		
1.1	Audio visual recording	Merging of recordings from 3 camera views and screen capture.	Multi-channel video
1.2	Observational data collection	Coding of multi-channel video with event variables representing multiple aspects of interactions	ODC log file with event occurrences and durations
1.3	Computer use	Measurement of keyboard and mouse use with User Action Recording (UAR) tool	Time-structured keyboard and mouse activity log files
1.4	Verbal interactions	Measuring the verbal interactions using Voice Activation Recording (VAR), combined with transcripts	Time-structured conversation log
1.5	Non-verbal interactions	Motion detection using PRS software. (Not reliably used.)	PRS log with time-structured motion indicators
1.6	Other inputs	Log File Aggregation (LFA) tool current version accepts up to 9 files	
2.	**Unification**	Aggregation of time stamped logs using LFA.	Aggregated output in XML or CSV format
3.	**Analysis**		
3.1	Identifying the sequence and patterns of interactions	Modelling of consultation process with UML Sequence diagrams, UML met-model for consultation.	Unified Modelling Language (UML) process models
3.2	Identifying the process map with activity occurrences and durations	Occurrence graph representation of aggregated observational data in LFA application. Video segments linked to events.	Occurrence graph with video segments.

Table 5.5: Stages of the ALFA approach for consultation observation

5.5.1 The ALFA tool-kit compared to other applications

An evaluation exercise was carried out to compare the position of the ALFA method compared to research tools with similar functionalities. The strength of the ALFA tool-kit is its modular nature, the comprehensive coverage of consultation interactions and the precision of the observations. The following two overarching objectives guided this evaluation exercise;

- Capacity to give prominence to the doctor-patient verbal and non-verbal communication whilst detailing the doctor-computer interactions
- Availability of the measurements capable of supporting the generation of UML sequence diagrams

The usability research approaches in the HCI domain are well developed. There are also applications developed to support qualitative research, capable of analysing the interaction in a wider context. Furthermore there are certain interaction recording techniques, capable of detailing selected aspects of interactions comprehensively and to support discovering of themes. Therefore, this evaluation focused on comparing the features of ALFA alongside nearest alternative applications from four research domains; (1) Qualitative research, (2) transcription based analysis, (3) usability testing and (4) screen capture based observation.

The six applications selected for the evaluation are listed in table 5.6. A summary of the evaluation results are presented in Appendix A. Except the DRS, the rest of the applications were previously evaluated (section 4.2) to assess their capacity to support consultation observation. The evaluation described here was carried out to recognise the 'state of the art' pertaining to the ALFA.

Application	Characteristics	Type
Digital Replay System (DRS)	•Supports managing, organising, synchronising, replaying and analysis of multimodal interaction data. •Capable of importing both raw and structured data. *www.mrl.nott.ac.uk/research/projects/dress/software/DRS/Home.html*	Qualitative research
Atlas ti	•Knowledge workbench software. •Facilities for analysing text and multimedia data. *www.atlasti.com*	
NVivo	•Features to code, classify, sort and organise data. •Collects information from rich or plain text documents, audio, video files and images. *www.qsrinternational.com/products/NVivo.aspx*	
Transana	•Transcription of audio or video clips to support their qualitative analysis. •Facilities to annotate segments of videos, introduce key words and to manage them based on file descriptive. www. Transana.org	Transcription analysis
Morae	•Usability testing suite for software applications and web sites. •Components for data collection, observation and presentation. *www.techsmith.com/morae.asp*	Usability testing
Camtasia	•Captures mouse movements visually. •Can add text notes. www.techsmith.com/camtasia.asp	Screen Recording
Adobe captivate	•http://www.adobe.com/products/captivate/Has a clip organising facility. •Captures mouse movements visually *www.adobe.com/products/captivate*	
BB Flash Back	•Single web cam stream can be linked in. •Mouse, keyboard interaction and audio time lines for analysis. *ww.bbsoftware.co.uk/BBFlashBack.aspx*	

Table 5.6: ALFA approach compared to similar other techniques

This evaluation element concluded the unique capabilities of the ALFA tool-kit. Some offer features capable of detailing only certain aspects of the consultation observation comprehensively. For example, Transana has constructive features for conversation analysis, Morae for usability testing, DRS for exploring social interactions and so on. However, ALFA offers a methodical approach for collection and analysis of interactions details, addressing both quantitative and qualitative aspects and also giving similar levels of significance to both human-human and human-computer interactions.

5.6 Observation of real-life consultations

After verifying the capacity of the ALFA approach to represent consultation interactions to a satisfactory level through a set of pilot studies, subsequent stages of this research focused on deploying it in real general practice consultations environments. Studying the conduct of the actual computer assisted consultations is essential to achieve the original research objective; assessing the influence of the electronic patient record features on the consultation process. Furthermore, there are aspects of the ALFA method's validity that are difficult to confirm solely based on simulated consultations. Key aspects that justify the need for using real consultation for this study are;

- **Standard working environment** - This investigation intends to measure the influence of the computer in standard consultation settings, in their daily use. Simulated consultations have limited capability in imitating those conditions. For example room size, lighting, noise, interruptions.
- **Unpredictability** - The unpredictability of the general practice consultations is impossible to mimic in simulated settings.
- **Complexity of the real medical record** - Medical records created for the simulated consultation may not be as complex or have sufficient historical information compared to those used in real consultations.
- **Doctor's familiarity with their usual environment** - Doctors usually prefer to consult in their familiar environments. Not knowing where to find the various printed forms, reference materials or devices they need, could influence the flow of the consultation. Seating position may also have an impact.
- **Task variations** - Simulated consultations may not possibly cover the range of tasks EPR systems are used for in real consultations.
- **Unknown contextual factors** - There could be valuable contextual information that influences the consultation process, which we are unaware of. They can not be identified without observing the real surgery sessions.
- **Variations in EPR system features** - Identifying the precise influence of different information systems features, require comparing their variation across different EPR systems and with larger samples. It is not practical to organise or anticipate all technical and functional variations using simulated sessions.
- **Consultations in succession** - Real consultations are done in succession. The way in which doctors progress through the list of appointments for the day could be having an influence of the time they spend for the initiation or conclusion of the consultation or on various other tasks. The influential nature of time and work pressure may not transpire in simulations.
- **Variations in technical profiles** – The success of the screen recording and UAR recording depends on the technical profile of the doctor's computer. Computer screen resolution, type of the video interface and the amount of space available to link the Framegrabber device influence the success of the screen recording. The success of the UAR might also depend on the type of keyboard and mouse connectivity, the native programmes running in the system, security settings and doctors' interactions with its interface.
- **Doctor-patient relationship and continuity of care** – Participants of simulated consultations may not have the similar levels of emphasis on the social aspects of the consultation as in real-life consultations. Assessing the influence of technology on the subtle-social interactions through simulated approaches may not be the most favourable approach.

- **Generalisability** – Use of only simulated scenarios for recognising the common computer assisted consultation tasks, patterns of computer use or influence of the computer could weaken the generalisability or recognition of the study outcomes.
- **Deployability in a busy surgery** - Time constraints and resources available to setup the tool-kit before the surgery session, monitoring its performance during the session and removing them at the end cannot be anticipated based only on pilot experiments.
- **Acceptance by patients and Doctors** – Regardless of the comprehensiveness of the technique, its utility as an approach for observation largely depends on the doctor's' and patients' view on its position in the consultation; whether it is an acceptable intrusion or unnecessarily influencing the consultation.

As a result, it was decided to use consultations conducted using four of the widely used brands of EPR systems; EMIS LV, EMIS PCS, INPS Vision and iSoft Synergy. The first system is a Character User Interface (CUI) type system, while other three systems represent the Graphical User Interface (GUI) type. At the time of the study, EMIS LV is the most widely used system.

5.6.1 Research ethics approval process

Recording real consultation requires ethical approval from national and local research ethic committees. Multi-channel video recording approach captures an audio-visual recording of the doctor and patient interactions, including patient face and voice. Screen capture element records areas of patient's medical record the doctor interacts with during the consultation. Therefore the recording process captures sensitive and patient identifiable information. Provided that certain recommended safeguards are met, recording of general practice consultations are regarded as ethically acceptable.

The research ethics approval process consisted of three stages representing different coverage levels.

1. Research Ethics Committee (REC) approval – The ethics approval request was made through the NHS Central Office for Research Ethics Committees (COREC, later became the National Research Ethics Service (NRES)). The ethical review was conducted and approved by the Southampton and South West Hampshire REC.

Study protocol supplied with the ethics application described the secure transporting, storage and access control mechanisms put in place to assure the safekeeping of the consultation videos and the sensitive information. Procedures for handling, processing, storing and destruction of the data have been compliant with the Data Protection Act 1998. The study received a favourable ethics approval (reference number: 06/Q1702/139). It was designated as not requiring a Site Specific Assessment (SSA-Exempt) that is no separate REC approval needed for new research sites.

2. Research site approval – Subsequently approval was sought from a selected set of GP surgeries to video record consultation sessions. This involved forwarding a formal request to the principal partner or the practice manager together with a copy of the REC approval. On receipt of a favourable reply, an application for a local NHS R&D approval could be submitted.

3. NHS R&D approval – These were requested through the relevant regional NHS Research Governance coordinators. In addition to the documentation supplied to the REC approval, this application required a Site Specific Information (SSI) form and the approval letter from the research site. The R&D approval for the GP surgery sites selected for this study were processed by four Research Governance coordinators; (1) South East London, (2) South West London, (3) North West London and (4) Sussex.

5.6.2 Selection of GP surgeries and recruitment of GPs

Research sites recruited for the study were on the whole identified through the network of teaching GP surgeries linked to the General Practice department of St George's University of London. Site identification was influenced by two factors;

- EPRS system used by the site – aim has been to have similar number of sites covering each of the four widely used EPR systems.
- Availability of one or more GPs with sufficient experience with the particular EPR system brand – To assure that users' familiarity with the EPR system is not influencing as a compounding factor, it was decided to recruit GPs with one year or more experience with the specific EPR system.

5.6.3 Patient recruitment and consenting process

Providing undemanding information and reassuring regarding the confidentiality have been central to the consenting process. The approach adopted for the patient recruitment consists of three stages.

The consultation session identified for the video recording were clearly marked by the practice staff in the appointment booking system. At the time of the booking, patients were informed about the research project by the surgery staff members and option to take part. In surgeries where patients are required to book their appointments several days in advance, those who booked their appointments in the 'video surgery' session received the research information sheets and the consent form by post. In surgeries where appointments are booked on the day, patients were given those documents when they arrive for the appointment.

In either situation, a researcher explained the objectives and the approach of the project to patients when they arrive for the appointment and supplied them with the information sheets. During the explanation, security measures in place, the data handling process and how to contact for further clarification or to express concerns were specifically emphasised. Those who are willing to participate would then sign the first part of the consent form before the consultation.

At the end of the consultation, patients were again approached by a researcher to verify their willingness for the research project to use the consultation's video. Those who agreed would then sign the second part of the consent form. Otherwise, the video file would be deleted immediately at the end of the filming session.

Patients were also told about the option of requesting the consulting doctor to turn the cameras off at any point of the consultation. Doctors were also instructed not to perform any physical examination in front of the cameras. The examination couch is not covered by any of the cameras angles.

Author coordinated and carried out all recording sessions used for this study. In three occasions, F2 doctors who were on their academic research appointments lend their assistance to recording sessions.

5.6.4 Recording process

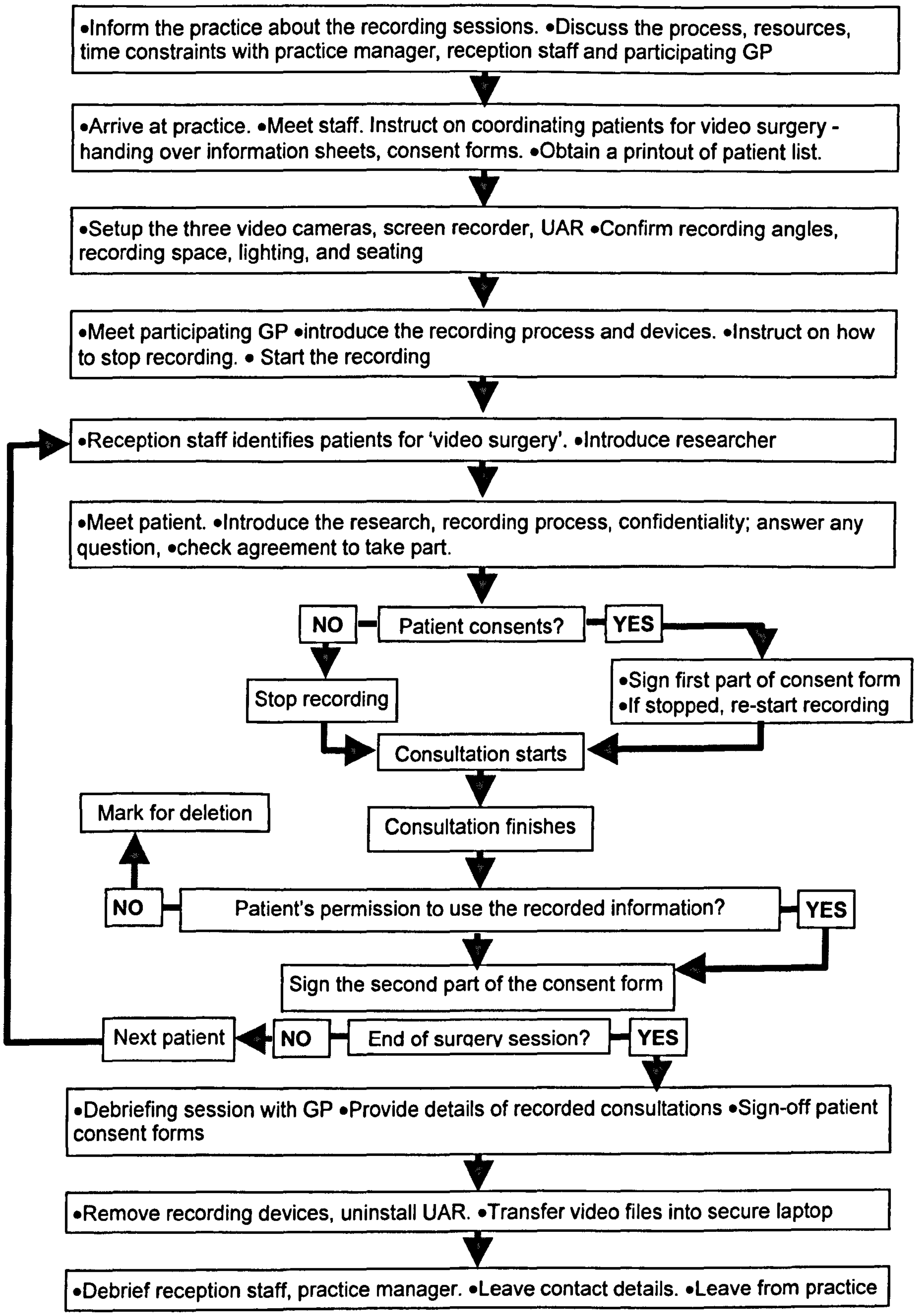


Figure 5.8: A diagram representing the video recording process at a surgery

5.7 Interaction variables

The detailed analysis of consultation interactions gave prominence to aspects of computer use tasks and their associations with doctor-patient verbal and non-verbal interactions. Author classified doctor-patient-computer interactions into singleton, episodic and continuous categories; depending on whether they occur throughout the consultation, intermittently or only once respectively. Each consultation video was rated five times to measure durations for a total of 36 different interaction types.

Having a tight definition for each of the interaction of interest is imperative for the reliability of the rating stage. Earlier pilot studies with ObsWin, user manuals and feedback received from raters recognised the need for clear variable descriptions. Therefore it was decided to create a set of '*interaction definition cards*'. Each contains following elements;

- **'Primary definition'** – A brief description of the interaction
- **'Includes'** – Observable tasks that should be considered under the specific category of interactions. This specifically lists the tasks that are apparent as well as those that have disparate characteristics, however need to be considered under this category.
- **'Excludes'** - This element describes those interactions that should not be considered under the particular category. These could be interactions with similar characteristics, however performed for to achieve a different purpose.
- **'Interaction start'** – The specific point of the interaction that should be considered as its start time.
- **'Interaction end'** - The specific point of the interaction that should be considered as its end time.

The final set of variables used with the ODC application for coding consists of six *continuous* and a total of thirty *episodic* and *singleton* type interactions (table 5.7). Rating process followed to measure both episodic and singleton type interactions were similar. The full set of definitions of *interaction definition cards* are supplied in Appendix B.

Continuous type interaction variables	
D	Doctor's computer use
R	Doctor looking at the computer screen
S	Doctor talking to the patient
K	Patient talking to the clinician
E	Doctor looking at the patient
T	Doctor and patient both looking at the computer screen
Episodic or singleton type interaction variables	
	a. Reviewing the medical record
1	Reviewing the past encounters
2	Reviewing of examination findings
3	Reviewing of test results
4	Reviewing letters attached to the patient's EPR
	b. Recording data
5	*Blood pressure recording*
6	Coded data entry
7	Free text entry
8	*Use of data entry forms/templates*
	c. Taking actions
9	Reviewing past medications
10	Prescribing – acute
11	Prescribing – new repeat
12	Prescribing – old repeat
13	*Issuing and printing prescriptions*
14	*Writing referral or other letters*
15	*Generating test requests – using electronic or paper based methods*
16	Referencing – using electronic or printed resources
17	*Referral – electronic or paper based structured methods*
	d. Overheads
18	System delays or errors
19	Incomplete/purposeless computer use
20	Responding to or reviewing prompts
21	Transitioning between EPR system's functional areas
22	Transitioning between EPR system and external applications
23	Other paper work
24	Other interactions
	e. Patient involved
25	Screen sharing
26	Reading or writing aloud
	f. Duration modifiers
27	Third party interruptions
28	*Physical examination*
29	*Patient in the consultation room*
30	Clinician not in the consultation room

Table 5.7: Set of interaction variables used to analyse the consultations (Singleton type variables marked in italic)

5.7.1 Interaction variable categories

Continuous variables

Three *Continuous variables* represent aspects of computer use while the remaining three measures verbal and non-verbal interactions between doctor and patient. As described in previsouly, these have been grouped across a number of separate rating runs to maximise the reliability of the rating process.

Rating run 1: **D**-Doctor's computer use, **S**-Doctor talking to patient,

Rating run 2: **R**-Doctor looking at computer screen, **E**-Doctor looking at patient

Rating run 3: **K**-Patient talking to doctor, **T**-Doctor and patient both looking at computer screen

Together with the initial viewing of the video, a typical 15 minute video requires at least one hour to complete all rating tasks. In average, considering the time needed for organising the source and output files set, the rating parameters and for error corrections author spent about two hours to rate a single consultation video.

Episodic and Singleton variables

These variables have been defined generally to describe the various aspects of computer use in detail; to recognise the variations in tasks carried out in a computer assisted consultation. There can be grouped into three main computer use task categories;

(1) Reviewing medical record
(2) Recording data
(3) Taking actions

Additionally, there are interactions representing unplanned activities, interruptions or overheads associated with computer use.

All 36 episodic and singleton interactions have been measured using a single rating run. A typical 10 minute consultation, requires about one hour to record all its non-continuous type interactions.

5.7.2 Automated processing of overlapping interactions

In most circumstances, there are multiple observable interactions at any given time in the consultation. For example, doctors talk while looking at the computer screen or free text entry could take place while patient is talking. Some of these overlapping interactions are particularly significant for understanding the influence of the EPR use on other consultation interactions.

In relation to two independent interactions, the episodes of overlapping could materialise in four different variations. For example, if A represents doctor looking at the computer screen and B represents doctor talking to the patient, type-1 represents situations where doctor started looking at the screen after initiating a verbal interaction with the patient, and stopped looking at the screen before concluding the verbal interaction. It might possibly represent an occasion where doctor entered a coded data item while summarising the problem to the patient. Figure 5.9 represents four possible variations where these parallel interactions could overlap.

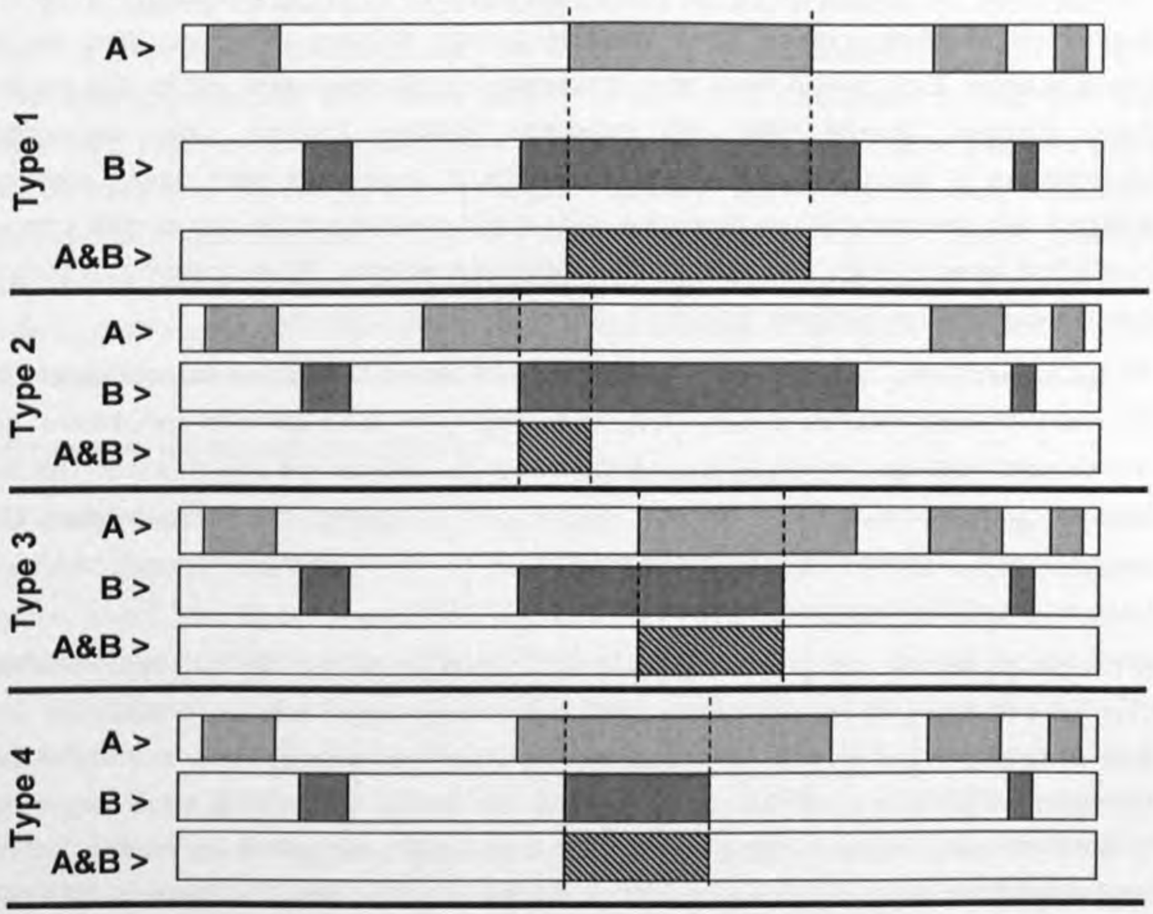


Figure 5.9: Four types of overlap that could take place between two interaction variables

From experience the author has observed that it is far more efficient to identify such overlapping interactions by processing the log files programmatically as an alternative for performing a separate rating exercise targeting them. Manual observation for overlapping interactions requires a greater understanding of the consultation content as they may occur less frequent, difficult to predict and might possibly require raters to change their focus between multiple areas in the screen rapidly. In addition, it is difficult to have variable representing overlapping interactions with those that represent non-overlapping interactions in the same rating run.

The author has created a separate java utility capable of generating the overlapping interactions automatically, which managed to process all possible interaction overlaps across the entire study sample and generate separate log-files in less than an hour.

5.8 Statistical analysis of quantitative data

Statistical analysis of time-structured data has been performed using PASW Statistics (formally known as SPSS) 17.0 software. A master table with profile data of all consultations was created first. This contained 163 cases, each representing one consultation. Its variables contain doctors' and patient's demographic data together with consultation summary statistics describing their characteristics, e.g. room layout, interruptions, total duration, computer use duration. This also contains binary type categorical variables representing the occurrence or non-occurrence of a particular incident, e.g. blood pressure entry, physical examination. Other interval type data columns represent total durations of observed interactions, e.g. total free text data entry time.

Another set of tables contained data representing each observed interaction; there are 30 individual tables. Each case in these tables represents a single observation with its start and end times, durations (interval data) and categorical variables (nominal data) representing characteristics of importance. For example, durations of coded data entry contain additional attributes with categorical values describing method of data entry and the type of code entered. Initially both types of tables were used to obtain descriptive statistics. When analysing the nominal data representing time durations, their distributions were initially observed.

As this research aims to distinguish the impact of EPRS system features on the consultation, the brand of EPR system was the primary element for grouping the observations for comparisons. Box whisker plots were used to visually contrast the differences between the time durations. This was followed by data analysis using one-way ANOVA tests to compare the means between EPR system groups. Statistical significance was assumed at $P<0.05$. When reporting results of ANOVA tests, equality of Variances was assessed using Levene's Test.

If the overall ANOVA results are significant, the implied rejection of the null hypothesis was interpreted as having at least one significantly different mean value. 'Post-hoc' comparisons were then performed in pair-wise, to identify the way in which means differ. Fisher's *protected* LSD (Least Square Difference) test was used for this purpose. It was selected while acknowledging the potential of having 'family-wise type I errors' (Tamhane, 2008) when performing multiple post-hoc comparisons and due to the existence of fewer number of groups (four EPR systems). The need for recognising any potential differences in the impact caused by distinctive information system features in each EPR system also influenced this.

Where relevant, the relationship of observations to doctor's and patient's age and gender were also explored. To assess the possibility of GP's style of computer use acting as a confounding factor in observed differences between systems, box-whisker plots were created, grouped by GPs for each system to analyse the data visually. Where necessary, another ANOVA test was performed to compare the means between individual GPs.

Multiple regression analysis using the backward stepwise removal method was used to recognise the potential predictor variables for the proportion of computer use. The author identified a total of nine potential predictors associated with clinician, patient and consultation characteristics, based on their relative importance in explaining the variance of the proportion of computer use. The categorical independent variable EPR brand was transformed into binary (dummy) variables and included in the regression as a block.

In situations where the distribution was not normal, author explored using log-transformed data or adopting nonparametric test. The Kruskal-Wallis test was used for comparing means, while Mann-Whitney test indicated the statistically significant differences between EPR system pairs. However, they did not have any influence on the previous interpretations. As ANOVA tests are generally considered as robust (Moore and McCabe, 2006) non-parametric tests have been used minimally.

5.9 Additional reference models used for analysis

To use as outlines for analysing the measured interactions and to improve the interpretation of observed phenomenon, the author used two additional reference models. Firstly, based on the understanding gained from pilot studies, different sections of the consultation duration have been recognised. They have been defined based on how the doctor-patient-computer triad take part in various interactions with respect to the consultation duration. The layout of the room, within which the consultation was conducted, is important when interpreting the influence of doctor's computer use on doctor-patient interactions. A classification for the consulting room layout based on the patient's chair position and who controls whether they can view or share the clinician's computer screen has also been used in this study

5.9.1 Parts of the consultation time-line

The whole period of the consultation is termed greater consultation; the doctor selecting the patient from the appointment list marks the start point, and the point where the medical record is closed in order to move back to the appointment list marks the end point. The period within the greater consultation where patient is present is termed as the core consultation, with the periods before and after the patient is in the room are the initial and final marginal consultation respectively. The core consultation is largely uninterrupted three actor time (UTAT); where the doctor, the patient and the computer can take part in meaningful interactions. The marginal consultation is generally bilateral (two) actor time (BAT), where only the doctor and the computer are present These consultation components and typical tasks performed in each section are further described in figure 5.10

5.9.2 Consultation room layout

The physical layout of the consulting room determines whether the patient can see the computer screen and view the data contained on it. Chris et al describe the layout of the consulting room in four categories:

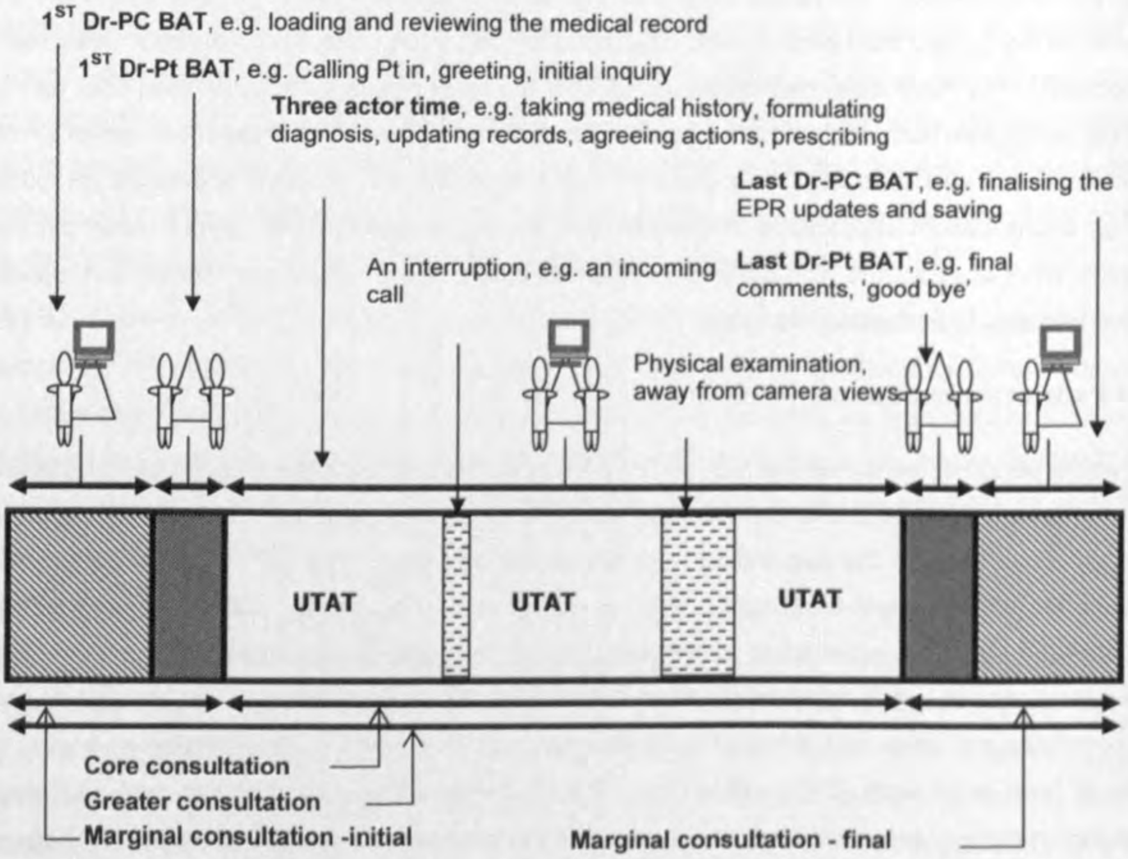
(1) Exclusive – where the patient sits opposite the clinician. It is generally impossible for the patient to view the computer screen – though sometimes the computer screen is set up in a way that it can swivel making it possible for clinician controlled patient access ;

(2) Clinician controlled semi-inclusive – where the patient sits to the side of the clinician's desk but the computer screen angle is such that the patient can only see the computer screen when the clinician turns the computer screen towards them;

(3) Patient controlled semi-inclusive – where the patient sits to the side and can see the screen when the clinician turns the screen towards them;

(4) Inclusive – where the patient, clinician and doctor sit in a triangular arrangement looking at the computer screen.

The fully inclusive setup has also been described as a "Triadic" relationship, where the patient-clinician and doctor are physically arranged in a triangle (Scott D et al, 1996). During the analysis stage the room layout categories were combined to obtain another derived variable with two categories: patient controlled and doctor controlled. Patient controlled category represents inclusive and patient controlled semi-inclusive layout, while Doctor controlled type includes the doctor controlled semi-inclusive and exclusive layouts.



BAT = Bilateral Actor Time, UTAT = Uninterrupted Three Actor Time

Figure 5.10: Components of the consultation duration

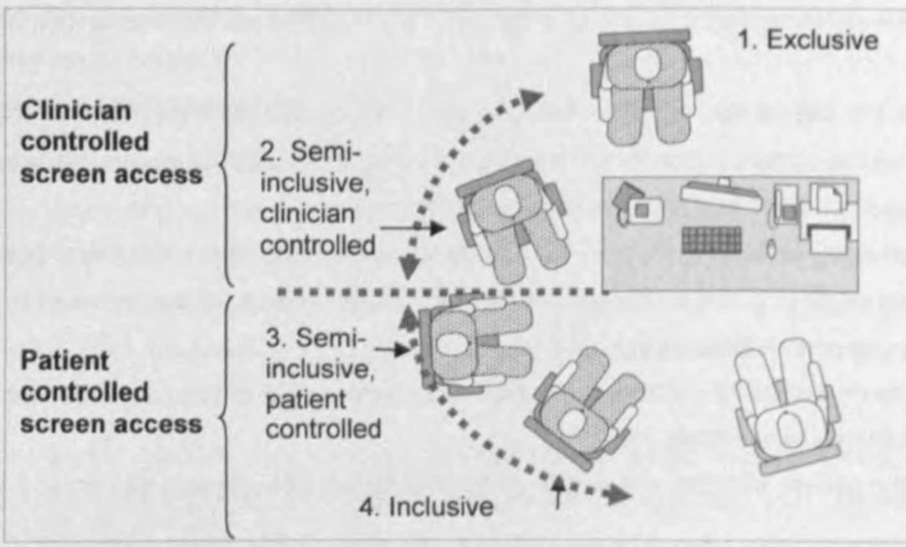


Figure 5.11: Classification of consultation room layouts

5.10 Summary

This chapter described the analytical approach adopted for this research. First it justified the selection of the UML Sequence diagrams for consultation process modelling. The complexity of the interactions involved, the presence of three active elements; the doctor, the patient and the EPR system and the influential nature of the task progression can be represented best using the UML Sequence diagrams. However, considering the amount of precision this study wish to achieve in terms of presenting the influence of computer system features to the social aspects of the general practice consultation interactions, a new Sequence diagram notation has been introduced. This was achieved by extending the features of the standard UML notation.

Furthermore, this chapter described a new framework introduced to categorise the consultation interactions; as (1) singleton, (2) episodic and (3) continuous. Under those categories, a total of 37 different interaction variables have been defined covering doctor-patient-computer interactions. Then a procedure to record consultations and to obtain analysis outputs has been set out.

This section also presented the details related to the ethics approval for the real-life consultation recording. A flow chart presents the activities associated with a recording session at a GP surgery. The consenting process involving both a member of the practice staff and a researcher present at the surgery's reception area is described. This approach involved seeking the patient's consent both before and after the consultation.

To support the analysis tasks associated with the research hypothesis, a number of reference frameworks have been introduced. They are aimed at enabling a more structured and reliable analysis of consultation interactions; to capture the totality of the consultation as detailed as possible while assuring that the findings are comparable with other similar studies. These reference models describe (1) different parts of the consultation time line, (2) patterns of interactions between the doctor, the patient and the EPR system and also (3) the physical layout of the consultation room. The next two chapters present the results from 163 consultations recorded with real patients, based on the analytical approach described in this chapter.

CHAPTER 6

Results I – Consultation's context and task durations

6.1 Introduction

This chapter introduces the first set of results associated with the sample characteristics and the contextual elements that appear to influence the consultations. The study sample is initially introduced with details of doctor and patient characteristics. Data collected has been from a sample of real life consultations with different doctors, in their normal practice settings. Observations based on consultations with four widely used EPR systems are reported here. Findings discussed here are first aimed at justifying the position associated with the first two sub hypotheses (H_{s1} and H_{s2}), where the capacity of multi-channel video based techniques to comprehensively observe the consultation is the focus.

This chapter also describes the position related to the sub hypothesis H_{s3}; the relationship the consultation's conduct has with its contextual elements. There are five characteristics of the consultation's context discussed here; (1) consultation room layout, (2) interruptions, (3) method adopted to call the patient in, (4) influence of patients being accompanied and (5) consultation initiator; as doctor, patient or computer. Influence of each aspect is considered, presenting the changes in the interaction durations and qualitative features linked to doctor-patient communication.

Presentation of the results then focuses on the consultation durations; which are linked to the research hypothesis H_{s5}.After describing the overall length of the consultation and its variations influenced by various factors, a detailed view of the consultation components is presented. This is done by considering the consultation as consisting of three parts as stated in the previous chapter; the core consultation bounded by initial and final marginal consultations. Different aspects of doctor-patient-computer interactions in respect to the consultation length are then discussed, with attention also given to the overlapping episodes amongst them.

Finally a detailed view of the computer use is presented, categorising them based on whether used for information retrieval, data recording or taking actions. This validates the position of the research hypothesis Hs4. Results are presented in detail subsequently to explain the outcomes associated with the hypotheses Hs6 and Hs7, focusing on common consultation tasks that come under each of the three main categories. Final sections of this chapter provide the necessary background to draw on the results presented in the next chapter where focus is on the consultation process models with influence made by specific system design features.

6.2 Sample characteristics

Multi-channel video recording of consultations took place in eleven different primary care surgery premises. They are from six Primary Care Trust (PCT) areas. The number of consultations used in effect is 163. Twelve (7%) of the 184 patients we approached for this study declined to participate, five (3%) of the recorded videos had technical failures and could not be successfully produced into multi-channel videos and further four videos (2%) were excluded due to the unusual amount of interruptions they contained.

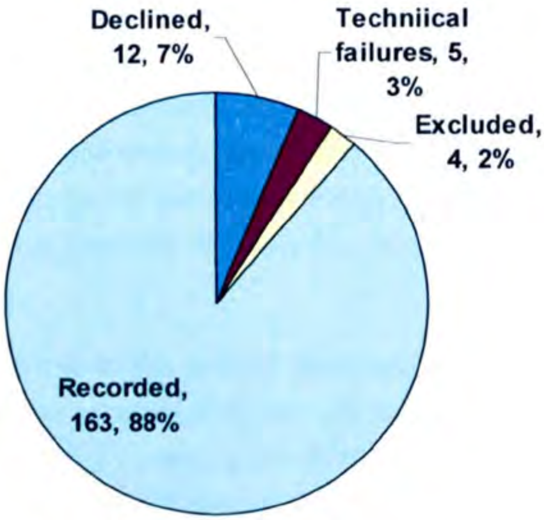


Figure 6.1: Summary of recruitment and recording outcomes

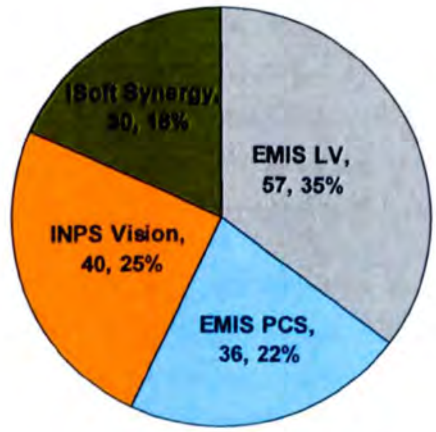


Figure 6.2: Proportion of recorded consultations by EPR brand

The largest number of consultations are with EMIS-LV (N=57, 35%), which also happens to be the most popular EPR system brand in the UK. A quarter of the recorded consultations are with Vision (N=40, 25%), while a slightly lower proportion is with PCS (n=36/163, 22%). Synergy accounted for the lowest proportion of recorded consultations (n=30/163, 18%). Accordingly, 65% (106/163) of the consultations were conducted with graphical user interface (GUI) systems, where mouse based interactions are common. LV is the only character user interface (CHUI) system in this sample, where most of the interactions with the system are done using the computer keyboard.

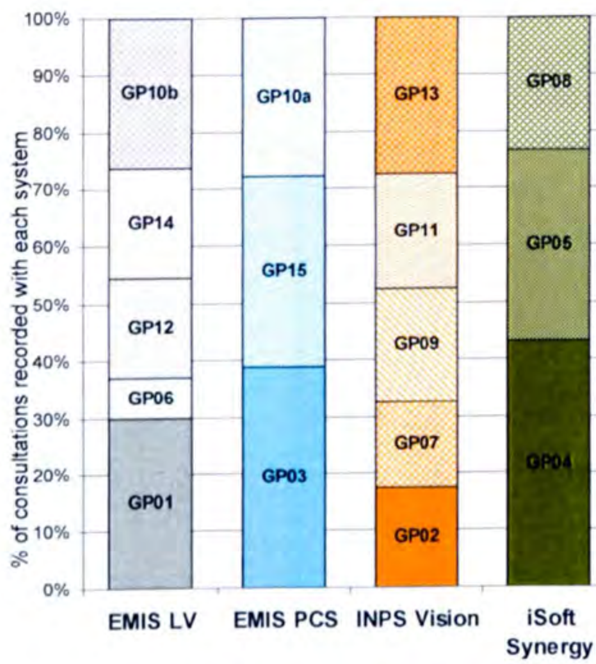


Figure 6.3: Distribution of the total number of consultations recorded with each EPR brand, between doctors.

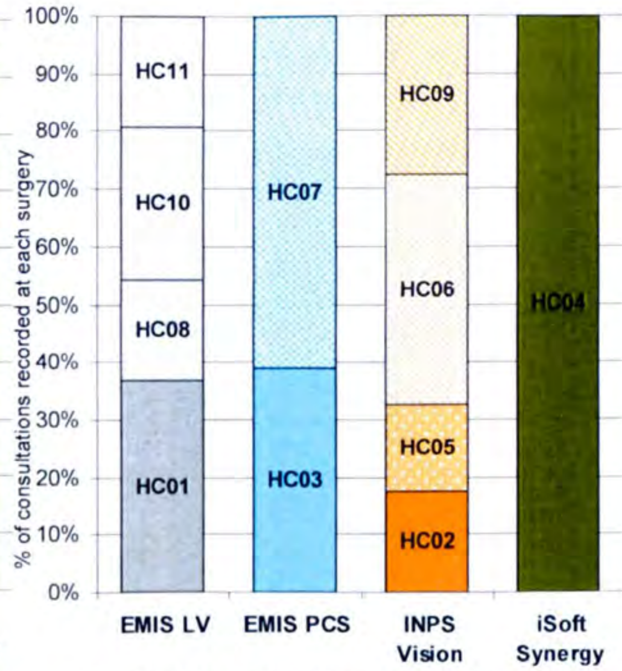


Figure 6.4: Distribution of the total number of consultations recorded with each EPR brand, between surgeries

LV and Vision consultations are from four different sites, while PCS are from two surgeries. All Synergy consultations are from three different GPs from a single surgery. Number of consultations recorded at each surgery ranged from 6 to 30 (mean=15, SD=7.2, median=14, IQR=8).

Consultations recorded at each surgery are from one to three doctors. All Synergy consultations are with three doctors from a single practice and 21 LV consultations (36.8%) are from two doctors (GP01 and GP04) from a single surgery. Three quarter of the PCS consultations are with two doctors (GP05 and 10a) from the same practice (HC07). Two doctors from a single surgery (HC06) contributed to 16 (64%) of the PCS consultation, with each doctor (GP09 and GP10b) contributing to exactly half of those consultations. One of the doctors that agreed to take part in the sudy was recorded with different two EPR systems, LV (n=15) and PCS (n=10) at two separate practices (HC07 and HC10). Mean number of consultations per doctor is 10 (SD=3.4, median=10, IQR=4.5) with a range of 4 to 17.

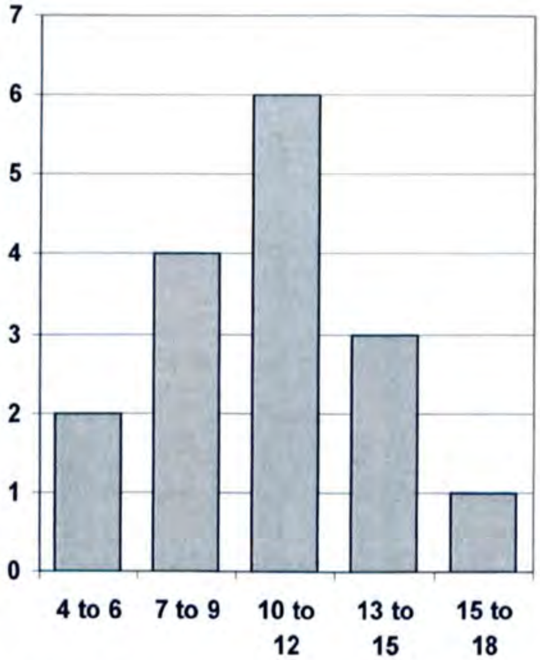


Figure 6.5: Number of doctors compared to the number of consultations recorded with each

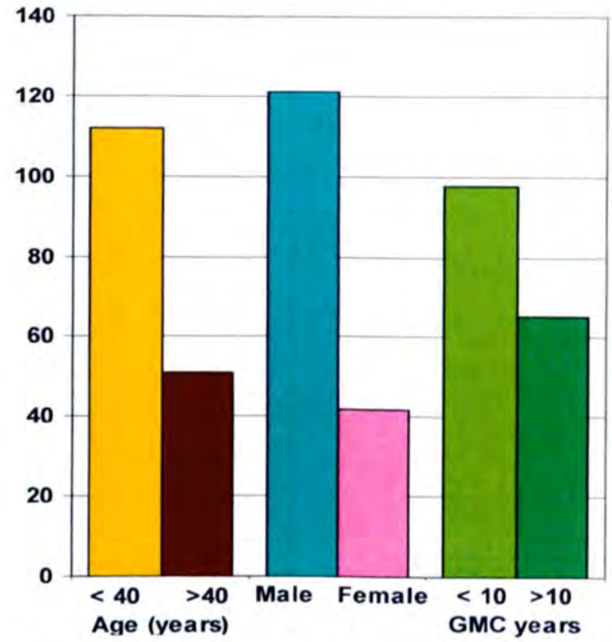


Figure 6.6 : Number of consultations compared to the consulting doctor's age, gender and years since GMC registration

Camera angles getting changed due to patients' movement resulted in having unusable recordings in two occasions. Unless the clinician is asked to assess the camera setup at the end of each consultation, it is difficult to avoid such incidents. Other three technical failures were due to errors in the screen capture process, caused by incorrect video resolution settings. Out of the four videos that were excluded subsequently, in two occasions doctor was interrupted by colleagues seeking advice and had to leave the consultation room for more than 50% of the consultation length. Another consultation where the patient took more than three minutes to arrive after doctor's announcement was also excluded. A small child accompanying one of the patients obstructed the camera angles regularly in a particular consultation, which also had to be excluded.

6.2.1 Doctor and patient characteristics

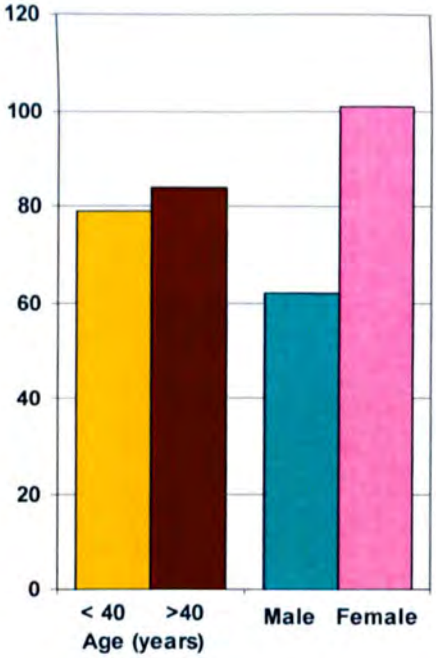
The availability of doctors within the study practices, who were willing to be videoed during their normal surgery sessions, influenced the characteristics of the doctor population in this study. Although the author attempted to keep the number of male and female doctors imilar, it was difficult to maintain such a balance while having to consider other factors like the availability of suitable surgeries, the local ethics approval and the specific type of EPR system needed. Nearly three quarter of the consultations in the sample are with male doctors (n=124/163, 74.2%). There were eleven male doctors and five female doctors altogether; male-female ratio is 2.2:1. Amongst the male doctors, the numbers of young and old doctors are similar. Only one female doctor belonged to the over 40 age category. The proportion of the consultations recorded with young doctors was about 70%, (n=112/163, 68.7%). There are six doctors in the sample who have been registered with GMC for more than ten years, only one of them is a female doctor.

Except PCS, all other EPR systems have been recorded with at least one female doctor and a doctor belonging to the 'over 40 years of age' band. All consultations with PCS are with male doctors who are less than 40 years of age, and 80% are with doctors who have been practicing for less than ten years. All systems recorded in the sample have users representing both categories for '10 years since GMC registration' band. However, for consultations with LV and Synergy, majority are with doctors that have been registered with GMC for more than ten years; 54.4% (31/57) of LV and 66.7 of Synergy (20/30) consultations.

	Consults'		EPR system				Dr gender		Dr age band		Dr GMC years	
	N	N%	LV	PCS	Visi'	Syn'	M	F	<40	>40	<10	>10
GP01	17	10.4	x				x			x		x
GP02	7	4.3			x			x		x		x
GP03	14	8.6		x			x		x		x	
GP04	13	8.0				x	x			x		x
GP05	10	6.1				x		x	x		x	
GP06	4	2.5	x				x			x		x
GP07	6	3.7			x			x	x		x	
GP08	7	4.3				x	x		x			x
GP09	8	4.9			x		x		x		x	
GP10a	10	6.2		x			x		x		x	
GP10b	15	9.2	x				x		x		x	
GP11	8	4.9			x			x	x		x	
GP12	10	6.1	x				x			x		x
GP13	11	6.7			x		x		x		x	
GP14	11	6.7	x					x	x		x	
GP15	12	7.4		x			x			x	x	
	163	**100**	**5**	**3**	**5**	**3**	**11**	**5**	**10**	**6**	**10**	**6**

Table 6.1: Characteristics of doctors that took part in the study; system they use, gender, age and years since GMC registration

The majority of the consultations are with female patients; 62% (n=101/163). The proportions of consultations with young and old patients are reasonably similar; 48.5% (79/163) of consultations are with patients who are under 40 years compared while 51.5% (84/163) from 40 years or older category. The male to female proportions is 1:1.6 within the sample. However, in the '25 to 49 years' age band, the number of female patients is nearly three times larger compared to that of male patients; the male-female proportion is 1:2.8. The proportion of consultations with female patients is higher in all systems, ranging from 58% in PCS consultations to 65% with LV. More than three quarter of the male patients have been seen by male doctors (n=49/62, 79%). Slightly lower proportion of female patients (71.3%) had their consultations with male doctors. The male-female proportion amongst the patients seen by male doctors is 1:1.47, while it is a slightly higher value of 1:2.2 for female doctors.



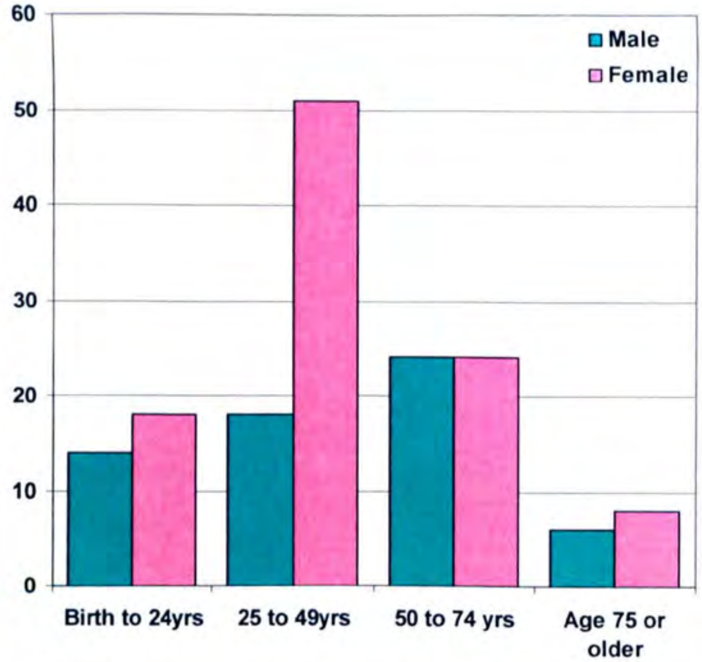


Figure 6.7: Number of consultations recorded compared with patients' age and gender profiles

Figure 6.8: Number of consultations recorded compared with 25 year age band of patients'

	Cons ultati ons, N	Doctor gender N%		Doctor age in 40 years band, N%		GMC registered years, N%		Patient gender, N%		Patient age in 40 years band, N%	
		Male	Female	< 40	> 40	< 10	> 10	Male	Female	< 40	> 40
LV	57	80.7%	19.3%	45.6%	54.4%	45.6%	54.4%	35.1%	64.9%	40.4%	59.6%
PCS	36	100.0%	0%	100.0%	.0%	80.6%	19.4%	41.7%	58.3%	61.1%	38.9%
Vision	40	47.5%	52.5%	82.5%	17.5%	82.5%	17.5%	37.5%	62.5%	52.5%	47.5%
Synergy	30	66.7%	33.3%	56.7%	43.3%	33.3%	66.7%	40.0%	60.0%	43.3%	56.7%
All	163	74.2%	25.8%	68.7%	31.3%	60.1%	39.9%	38.0%	62.0%	48.5%	51.5%

Table 6.2*:* Proportions of recorded consultations by doctor and patient characteristics

6.2.2 Patients' reaction to the consenting process

Out of the twelve patients who declined to take part after having been introduced to the study, the nature of the problem they wish to discuss was mentioned as the reason for refusal by eight patients. The remaining four patients did not cite any specific reason, other than their personal inclination for not to be videoed.

It was author's experience that the way in which this particular process is handled as having an important influence on the decision a patient makes on their participation. An initial mentioning of the fact that the consultations are being recorded by the practice's reception staff, either at the time of booking or at the reception followed by a detailed explanation from the author resulted in a higher proportion of patients agreeing to take part. The initial set of refusals encountered could particularly be linked to the method of consenting employed at the beginning. Mostly due to the work pressure, practice staff failed to explain the objectives of the study with sufficient detail, and the reduced level of confidence staff showed while explaining were particularly visible. Reception staff were also unable to spend a consistent amount of time introducing the study to all the relevant patients. When theauthor decided to be present in the waiting area, with a list of patients booked in to see the particular GP, and started introducing the study details to the relevant patients individually, patients showed more interest on the study. Though this approach assured that each of the patients is getting sufficient amount of time to know about the study, receive comprehensive information and to seek any further clarification, still there were occasions where patients felt less comfortable of being approached by an 'outsider'. This was despite the fact that care has been taken to present author's credentials.

When it was decided to adopt the approach, where reception staff would briefly mention about the study to the relevant patients, give information leaflets followed by introducing and directing them towards the researcher to discuss further about the study, the number of patient approvals increased. The acquaintance patients had with the 'usual' reception staff of their doctor's *surgery* assisted in establishing the initial confidence about the research and the credibility of the researcher who was present in the waiting area. The explanation by the researcher which followed then enhanced this understanding. After the adoption of this method of patient recruitment, only one patient refused to take part citing personal concerns.

None of the patients asked to turn the cameras off during the consultations. All patients who agreed to take part in the study completed the second part of the consent form after their consultations, expressing there agreement for the use of video recorded observations for this study.

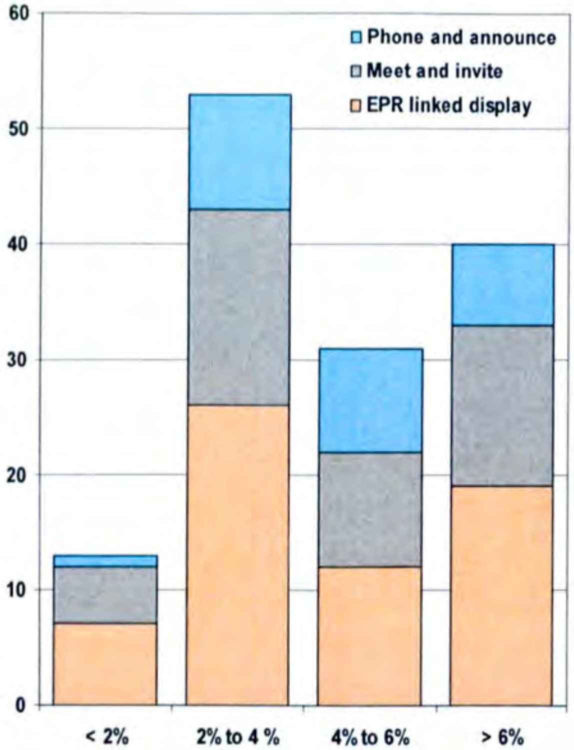
6.3 Consultation overview – context

6.3.1 Patient calling-in method

How the patient is called into the room affects the start time of the core consultation. Clinicians selected the patient from the appointment list and initiated the linked medical record, spent time reviewing the past encounter details, latest test results or responding to any presented prompts before deciding to invite the patient in. patient call-in approach could not be rated in 26 (15.9%) consultations; eight were due to technical reasons. In four occasions, the patient for the subsequent appointment came into the consultation room as an accompanying family member.

In average, calling-in could take about 6% of the greater consultation (mean =5.74%, SD=5.76%, median=4.11%, IQR=3.35). Doctors who were using the over the phone announcement and digital display approach spent quite similar proportions of the consultation time (5.02% and 5.09%) waiting for the patient to arrive (SD=2.37%,median=4.41%, IQR=2.85% compared to SD=4.48%, median=3.95%, IQR=3.71).

Physically collecting patients is the slowest (mean=45.6s, SD=44.6s), taking nearly 7% of the greater consultation time (mean=7%, SD=8.14%, median=4.10%, IQR=3.64%). This was observed in 46 consultations (28.2%). Doctors adopting this approach reviewed the record and walked out of the consultation room to announce the patient's name at the reception area.



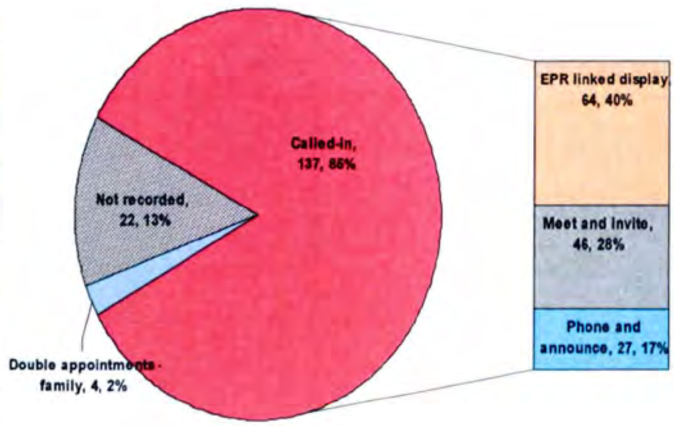


Figure 6.9: Proportion of the consultation spent waiting for the patient to arrive and method used to call-in

Figure 6.10: Patient call-in methods observed within the study sample

The time spent on calling the patient in is not significantly different between the three approaches (p=0.157). Similarly, the consulting doctor, doctor's or patient's gender or doctor's age did not cause a significant difference (all p>0.1) on the proportion of time spent on patient calling-in. However, this time difference is marginal for the EPR brand (p=0.058).

Doctors that used either of the remote call-in approaches seemed to be aware of the typical time that takes for the patient to arrive after the announcement, and usually made use of that time gap to continue their interactions with the EPR. Consultations involving elderly patients took significantly longer (p=0.042); 6.7% (SD=7%) of consultation length for over 40 years old compared to 4.7% (3.9%) for younger patients.

Over the phone announcement is the fastest approach to notify patients to arrive-in (mean=27.3s, SD=15.6s). Nevertheless, this also happens to be the least common (17%, 28/167). Most of the time doctors announced the name of the patient and the consultation room number. In some occasions doctors also indicated the exact location of the room, especially when consulting room is located in a floor different from that of the reception area. Doctors pressed a specific activation button to link their telephone to the announcement system available in the reception area, and announced the name reading from appointment list on the EPR screen.

Inviting patients using a digital display screen located in the reception area, linked to the EPR system was the commonest (39%, 65/163). This has a slightly higher mean duration compared to over the phone announcing (mean=30.3s, SD=19.2s), and was observed in all systems except with Synergy; 78% in PCS, 39% in LV and 15% in Vision. The digital display mounted in the reception area makes a distinctive 'beep' sound before displaying the patient name, doctor's name and the room number. In those practices patients seem to be used to gaze at the LED screen with each notification. This approach took longer in situations where patients were not familiar with the room's location, sometimes they asked for directions from other patients or practice staff. Regardless of the method of calling-in, in all occasions the doctors waited until the patient is seated to inquire about the reason for attendance.

Patient calling-in method	Time taken to initiate the consultation since the calling-in interaction								Consults' count	
	Duration (mm:SS)				Proportion of greater consultation (t%)					
	X	SD	M	IQR	X	SD	M	IQR	Total N	N%
All types	00:35	00:30	00:29	00:18	5.7	5.8	4.1	3.4	137	84.1
EPR-linked display	00:30	00:19	00:28	00:18	5.1	4.5	4.0	3.7	64	39.3
Meet and invite	00:45	00:45	00:29	00:23	7.1	8.1	4.1	3.6	46	28.2
Phone and announce	00:20	00:11	00:19	00:13	5.0	2.4	4.4	2.9	12	22.2

Table 6.3: Different methods doctors used to call their patients in; as durations, proportions of the consultation

6.3.2 Room layout

A combination of the physical layout of the room and the doctor's actions determined the extent to which a patient might view and interact with their computer record. Only one GP (6.3%, 1/16) had the patient sit alongside in the inclusive position; quarter of the clinicians (25%, 4/16) had the patient in the patient-controlled semi-inclusive position. The commonest room layout (62.5%, 10/16) had the patient in the doctor controlled semi-inclusive position where they could not naturally observe the content of their EPR without changing the seating position or clinician turning the computer screen. Consequently, majority of the consultations are in rooms with the clinician controlled screen access setup (63.5%, n=106/167).

With the exception of Synergy, all other EPR systems have been recorded in both patient and doctor controlled inclusive setups. Consultations with Synergy are only from consultation rooms in inclusive and doctor controlled inclusive setup while all consultations in exclusive setup are with Vision EPR system. EMIS LV was used proportionately the most in patient inclusive consultations; INPS Vision was used proportionately least.

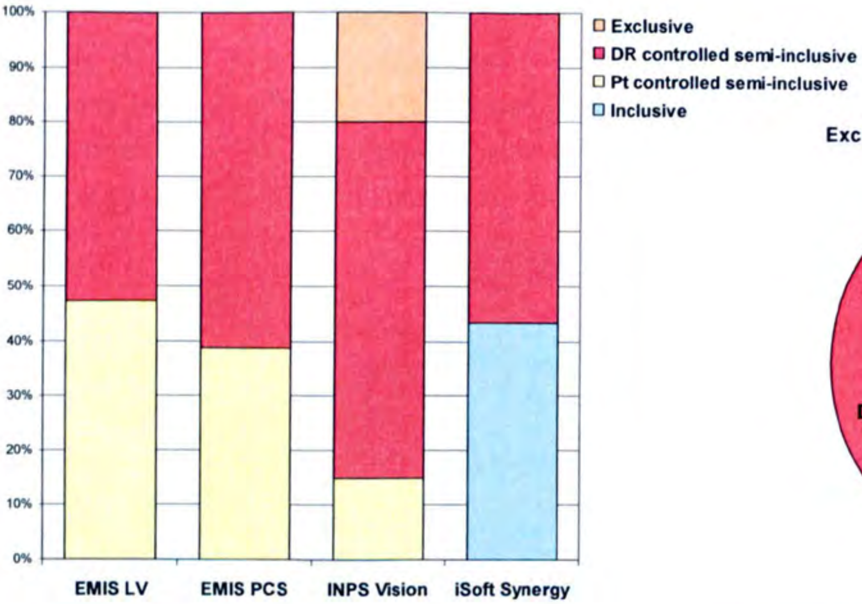


Figure 6.11: Consultation room layouts and the EPR systems used

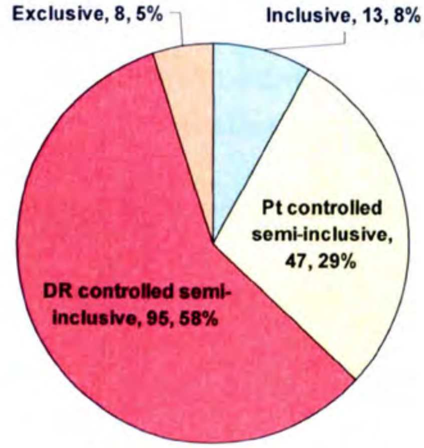


Figure 6.12: Number of consultations compared to room layouts categories

Female doctors and those from the less than 40 year's old age band are mostly having the doctor controlled semi-inclusive layout, whereas older doctors were recorded in the patient controlled semi-inclusive setup; $p<0.001$ for both doctor age and gender differences. One male doctor in the over 40 year's category had an inclusive layout, and one younger male doctor had an exclusive arrangement with the patient sitting opposite. Three of the four female doctors in the sample used a doctor-controlled semi-inclusive style. There were no difference in the age-sex profile of the patients attending the different consulting room layouts; either when two or four categories of layout were compared. There was no difference in the age-sex profile of the patients associated with the layout of the consultation room.

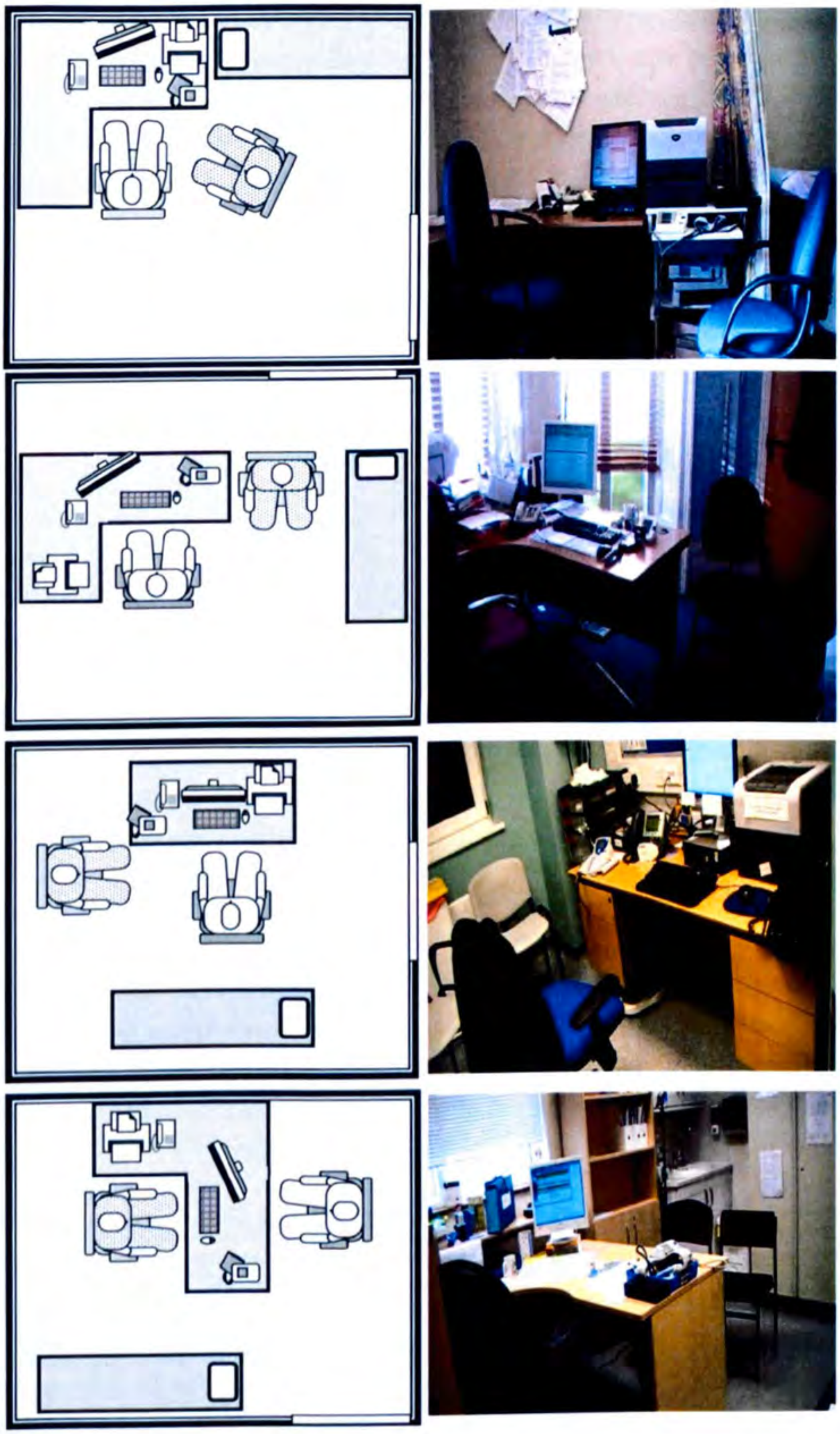


Figure 6.13: Room layouts observed in the study sample; from top to bottom: inclusive, doctor controlled semi-inclusive, patient controlled semi inclusive and exclusive

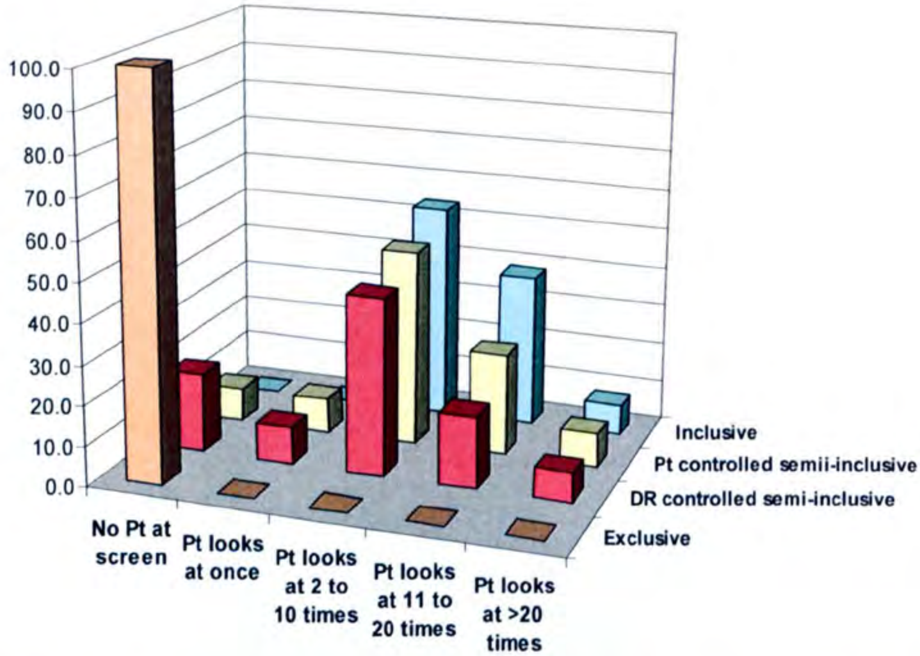


Figure 6.14: Proportions of the consultations, compared to number of times patients were looking at the computer screen and room layout categories

Clinicians spent more time ($p<0.001$) looking at the computer screen when patient is seated in an inclusive setup; mean proportion of the greater consultation looking at the screen is 17.6% (SD=20.7%) for the inclusive or patient-controlled inclusive layout compared to 5.6% (SD=7.5) in doctor controlled layout.

Neither the doctor-patient verbal nor the non-verbal interactions were significantly influenced by the room layout, for example the number of eye contacts are almost identical in both doctor-controlled and patient controlled layouts (30.3% and 30.4%;p=0.98), amount of computer use during verbal interactions are also similar (15.9%, SD=10% compared to 14.6%, SD=8.8%, p=0.4). The overall computer use was also not affected by the room set-up; 35.9% (SD=15.9%) in patient controlled compared to 34.4% (SD 15.4%) for doctor controlled screen access (p=0.55).

In doctor-controlled layouts, the proportion of the greater consultation time doctors spent looking at the computer screen without performing a specific task is significantly shorter ($p<0.001$); mean proportion of 5.6% (SD=7.6%) compared to 17.6% (SD=20.7%) for patient-controlled layout. Consultation rooms arranged to the opposite setup, the patient-controlled or inclusive provided more openings for clinicians to look at the screen. Since patients could more directly observe and probably were more aware of the nature of doctor-computer interactions, patient controlled setups seem to allow more freedom for clinicians to interact with the computer as and when needed. In other words, clinicians seem to be less obliged to make eye contact during computer use. Doctors were happy to engage with patients during free text entry in both inclusive and patient controlled layouts. About twice the number of eye contacts could be observed (mean=3.7, SD=3.6) compared to the doctor-controlled layouts (mean=2.1, SD=1.7; p=0.029) and patients talked more (mean=8.2, SD=8.1 compared to mean=5.2, SD=4.2; p=0.04).

The number of times patients looked at the screen per consultation, when considered proportionate to the total number of consultations from each room layout type, increases from doctor-controlled to semi-inclusive patient-controlled screen access, with inclusive layout having the highest. In all consultations recorded in inclusive room layout, patient looked at the screen; in fact patients looked at the computer screen twice to ten times in more than half of the consultations (53.8%, 7/13). When patients had the option of looking at the screen, they did not do so in only 8.5% (4/47) of the consultations. Even in the situations where they have to make an effort to have a view of the screen, patients looked at the screen in 80% (76/95) of consultations. When the number of consultations, where patients were looking at the screen multiple timer are considered, after the inclusive set up (100%), patient-controlled screen access is the next highest (83%, 43/47), with the doctor-controlled layout having the lowest proportion (69.5%, 75/95).

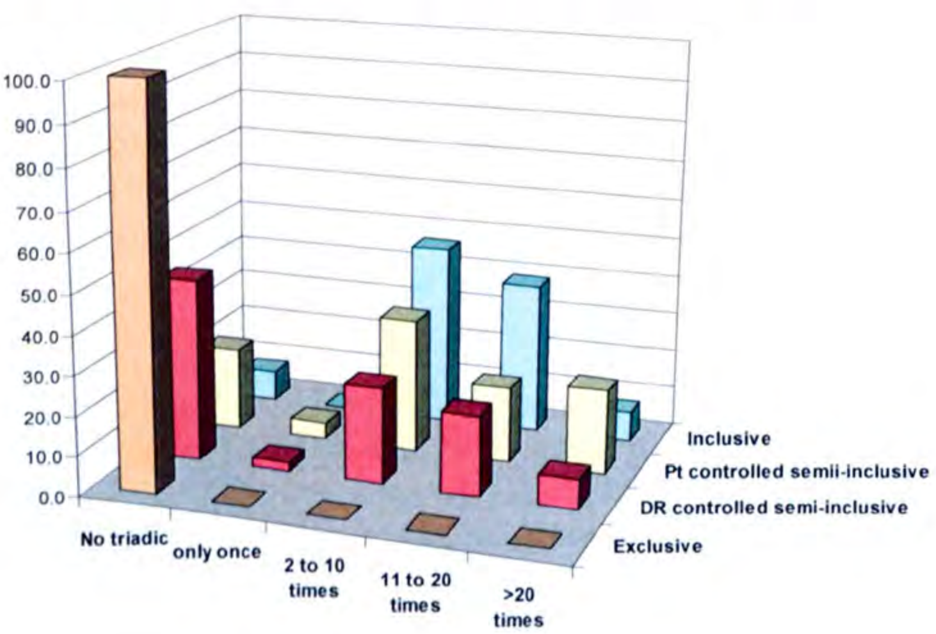


Figure 6.15: Proportions of the consultations, compared to number of times both doctor and patient were looking at the computer screen, compared to room layout categories

Incidents of doctor actively sharing the computer screen with patient occurred in 13 consultations (8%, 13/167); none of them were observed in the doctor-controlled layouts (Chi square $p<0.001$). About half of those consultations (7/13, 53.8%) had only a single episode of screen sharing interactions, maximum occurrences observed was four. In consultation rooms with exclusive layout, unless clinician decided to swivel the computer screen almost half a circle, or invited the patient to stand up and come around, screen sharing is not practical. This arrangement of room did not support any 'triadic' viewing of the EPR. Even in the commonest semi-inclusive layout, doctors had to turn the screen towards the patient before initiating screen sharing episodes in 10/13 (77%) of occasions.

More than 90% (n=12/13, 92.3%) of the consultations recorded in rooms with inclusive layout had situations where both doctor and patient are looking at the screen at the same time. In patient controlled semi-inclusive rooms this occurred in three quarter of the consultations (n=37/47,78.7%).

The doctor-controlled semi-inclusive category had about half of the consultations (n=51/95, 53.7%) with these 'triadic' incidents. If patients in rooms with inclusive setup decided to look at the screen, they always did so multiple times. The proportion of the core consultation, which is 'triadic' is about 10% (SD=9.1%) in the patient controlled setup, while doctor-controlled layout has a lower amount (7.4%, SD=7.8%).

There are very little differences in the number of triadic episodes (mean=13, SD=11.5; P=0.65) or their total durations (mean=49s, SD=45s; P=0.95) between the four EPR systems. The proportionate length of 'triadic' durations out of the core consultation is also similar (mean=8.9%, SD=7.8%, P=0.54).

6.3.3 Interruptions

Interruptions were a standard part of the consultation for most GPs (27.6%, n=45/163), some had multiple interruptions (3.1%, n=5). Doctor leaving the room (12.3%, n=20) were also common. Interruptions occurred mostly in the core consultation (75%, 40/53), however with a mean duration of 45 seconds (median=20s IQR=41s) they appear to be longest when they occurred in the final marginal consultation. The mean length of the interruptions noted in the core consultation is 34 seconds (median=24s, IQR=22s), which is just under 5% of the average greater consultation length.

Consultations with the Vision EPR system had the highest number of practice related interruptions (n=14/34, 41.2%); remaining interruptions of this type were almost equally distributed among the other three EPR brands. When all interruption types are concerned, least were observed in consultations with LV (n=8/45,17%) while Synergy is associated with the most incidents (N=19/45,42.2%). No study related interruptions occurred in LV consultations.

The mean length of the observed interruptions is just over half a minute (mean=33s, SD=34s). Duration of practice interruptions (mean=36s, SD=40s) are in fact longer than those related with the study (mean=26s, SD=18s). Telephone calls doctors received or made during consultations were the most frequent non-study type interruption; they have a mean duration of 39 seconds (SD=38s) and 1:22 minutes (SD=3:08 mins) respectively. The longest interruption observed was associated with a call which a doctor made to inquire about a hospital letter, taking more than three minutes (3:12mins). However, in-coming calls are the commonest, of which the longest duration observed is 2:12 minutes. It was a call made to a practice staff members and was unrelated to the ongoing consultation. Staff members walking in to the consultation is the next commonest reason for interruptions; on two occasions doctor's colleagues interrupted to seek advice, another occasion by a trainee doctor and the remaining are from other practice staff requesting doctor's authorisation for prescriptions. One of the three interruptions labelled in figure 6.17 as 'other' was a result of the doctor completing the medical record of the previously seen patient, while another interruption (t=57s) in the same category represents the time spent on adjusting the computer screen (1:09mins). The remaining 'other' type interruption (60s) is caused by a family member accompanying the patient.

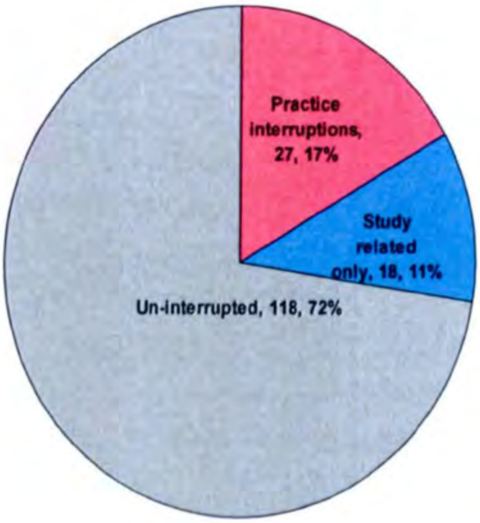


Figure 6.16: Proportion of consultations with interruptions

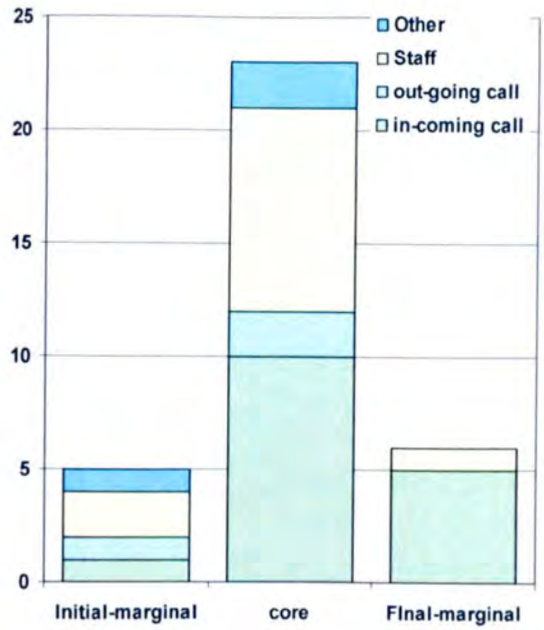


Figure 6.17: Distribution of interruptions across core and marginal consultations

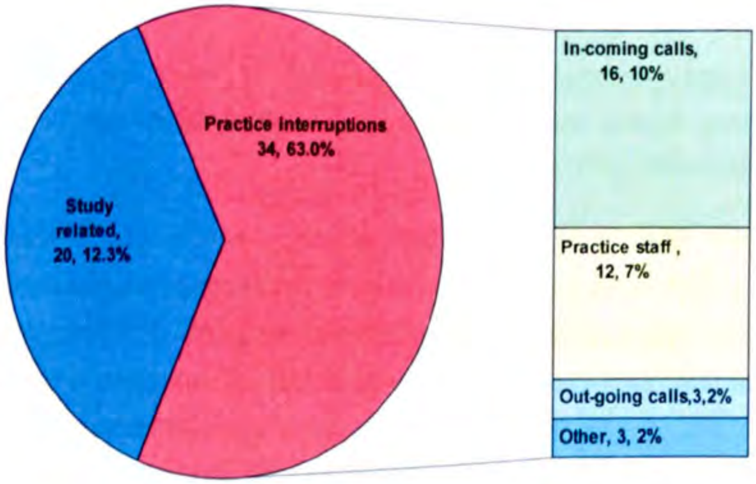


Figure 6.18: Proportions of practice interruption types

Three quarter of the doctors (n=12/16, 75%) who participated in the study faced practice interruptions. Consultations recorded from one of the surgeries did not have any non-study related interruptions. There were 14 (8.5%) consultations from this practice. Out of the 27 consultations with practice interruptions, nearly a quarter (7/27, 25.9%) had more than one interruptions. Two of them had a combination of study related and practice interruptions. In the remaining three consultations with multiple practice interruptions, one was in fact interrupted three times by in-coming phone calls.

Patients deciding to fill-in the consent form towards the end of the consultation are the primary reason for the study interruptions. On six occasions (3.6%) patients decide to inquire about the objectives of the study from the doctor.

Patient calling-in method	Period of interruptions								Consultation count	
	Duration (mm:SS)				Proportion of greater consultation (t%)					
	X	SD	M	IQR	X	SD	M	IQR	Total N	N%
All types	00:33	00:34	00:20	00:23	4.6	4.3	3.1	3.8	54	33.1
Study related	00:26	00:18	00:20	00:11	4.4	3.3	3.0	2.8	20	12.3
Practice interruptions	00:36	00:40	00:23	00:37	4.7	4.8	3.1	5.3	34	20.9
In-coming calls	00:39	00:38	00:24	00:45	4.5	3.5	3.5	5.1	16	9.8
Out-going calls	01:22	01:39	00:48	03:08	10.7	11.5	7.9	22.4	3	1.8
Staff	00:20	00:11	00:19	00:13	2.8	2.0	2.6	1.9	12	7.4
Other	00:41	00:31	00:51	01:00	7.2	7.4	5.9	14.6	3	1.8
Initial-marginal	00:15	00:07	00:16	00:12	2.88	1.47	3.31	1.85	5	3.1
Core	00:34	00:28	00:24	00:22	4.88	3.49	3.75	3.68	40	24.5
Final-marginal	00:45	01:04	00:20	00:41	5.56	7.50	2.53	5.01	8	4.9

Table 6.4: Interruptions observed in the study sample; as durations, proportions of the consultation

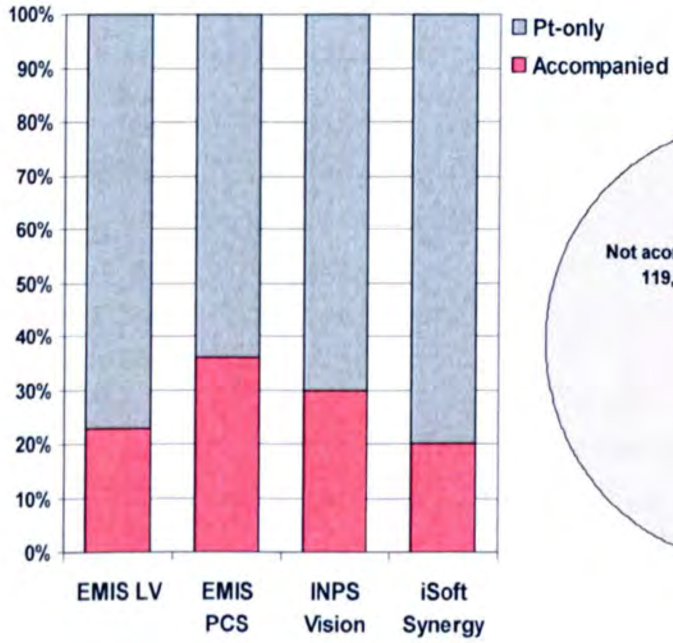
6.3.4 Accompanied patients

In consultations where the patient was accompanied by family members or friends, the proportion of time spent on computer use is significantly reduced. More than quarter of the consultation had an additional person other than the patient (27%, n=44/163).

The majority of the consultations with third parties are situations where patients arriving with either their children or parents (70.4%, n=31/44). In three such occasions, the subsequent appointment was for the accompanying child and doctors still had to follow the usual sequence of interactions to close the existing medical record and open the new one. Nine (5.5%) consultations were with patients who came with their husband or wife, one of which is a family appointment where both husband and wife were seen by the doctor and their individual EPR records were updated.

In twelve consultations (7.4%) where the patient was below nine years of age, the accompanying parent was the main party that took part in doctor-patient interactions. Out of the eleven consultations with patients in the 15 to 19 age group, seven were accompanied by parents. Five of the 27 consultations with elderly patients (age over 70 years) had their spouse during the consultation. In both those situations, generally both patient and the accompanying person verbally interact with the doctor. In occasions where parents broght their school (n=2) or pre-school age (n=4) young children, no note worthy influence to the consultation work flow is visible. However in two occasions doctors moved away from the main consultation area to organise additional seating. One consultation recording had to be excluded due a toddler spending a considerable amount of time looking into one of the cameras.

The presence of an additional person did not have a significant influence on the consultation length (p=0.4), nevertheless the mean duration of accompanied consultations are slightly longer (12:22mins compared to 11:37mins). Neither the proportion of final-marginal consultation (mean=8.2% compared to 7.8%, p=0.8) nor the use of computer (mean=78.0% compared to 73.6%, p=0.527) in that period significantly increased, regardless of having extra person or persons during the core consultation.



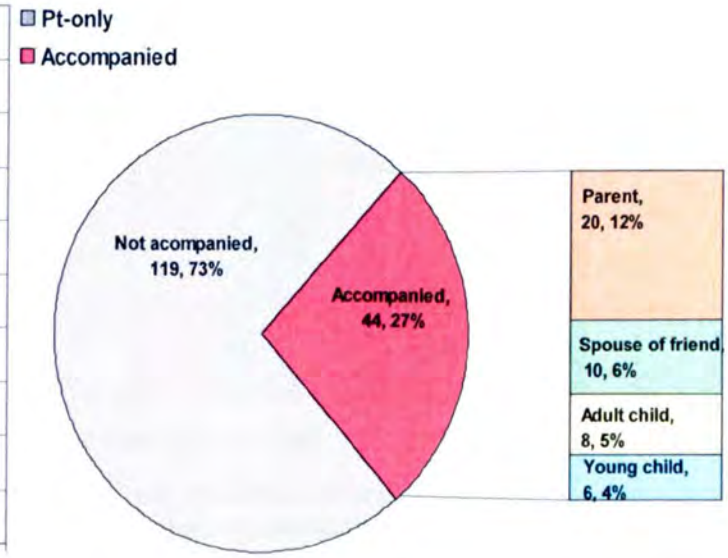


Figure 6.19: Proportion of consultations with accompanied patients, by EPR system

Figure 6.20: Proportion of consultations with accompanied patients, by relationship to the accompanying person

Patients being accompanied seem to have reduced the time spent on the computer use; this is significantly reduced compared to consultations where only doctor and patient are present. When patient is accompanied, the mean duration of computer use within the core consultation was 29%. In the un-accompanied category this is 37.16%; a significantly higher proportion (p=0.003). Similarly the total computer use within the un-interrupted greater consultation is lower (mean = 41% compared to 50.1%) and the amount of time doctors verbally interact without using the computer is longer (mean = 49.3% compared to 42.4%); both are significantly different (p<0.001 and p=0.004 respectively).

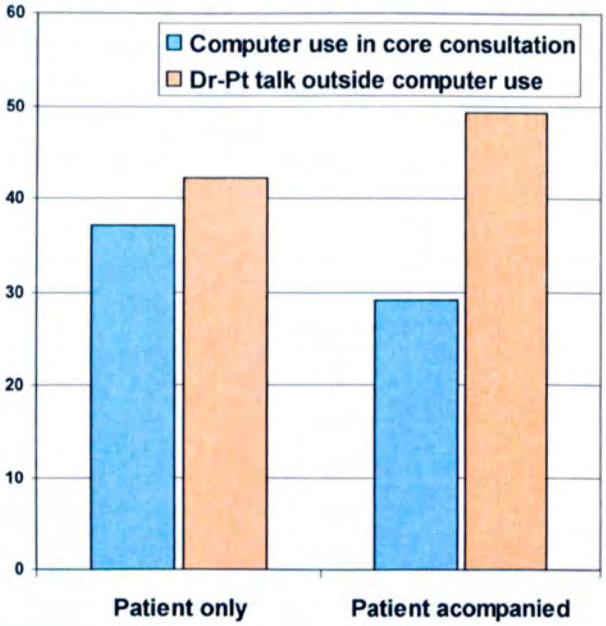


Figure 6.21: Changes to the computer use and verbal interactions proportions when patient is accompanied

	Proportions (t%)					
	ẋ	SD	X	IQR	Min	Max
Computer use within core consultation						
All	47.7	14.4	48.6	21.4	11.8	80.9
Patient only	50.1	13.8	50.9	19.2	13.0	80.9
Patient accompanied	41.1	13.9	42.6	19.4	11.8	75.1
Computer use within uninterrupted core consultation						
All	35.0	15.6	36.5	23.7	2.8	75.4
Patient only	37.2	15.5	39.9	23.6	2.8	75.4
Patient accompanied	29.0	14.6	26.5	20.5	5.5	68.8
Doctor-patient talk without computer use						
All	26.3	17.7	20.1	28.4	17.4	5.8
Patient only	39.2	37.5	24.2	57.1	12.6	2.9
Patient accompanied	82.2	98.6	47.7	193.5	5.5	5.5

Table 6.5: Changes to the doctor-patient-computer interactions when patient is accompanied; as proportions of the consultation

6.3.5 Consultation initiation

The consultation initiator seems to influence the proportion of time doctors spend reviewing the past medical history and the amount of computer use before the core consultation, however with no effect on the overall computer use. The amount of doctor-patient interactions is also modified by the fact whether the consultation was initiated by the patient or not.

In 7.4% of the study consultations, (n=12/163) the computer initiated the consultation. In those consultations, medication review reminders, prompts indicating incomplete data related to current problems, especially those related to the quality targets and alerts about test results influenced the doctor's agenda for the consultation. A quarter of consultations were (24.5%, 40/163) patient initiated. Doctors were responsible for the way in which the consultations were initiated in the remaining 68.1% (n=111/163) consultations.

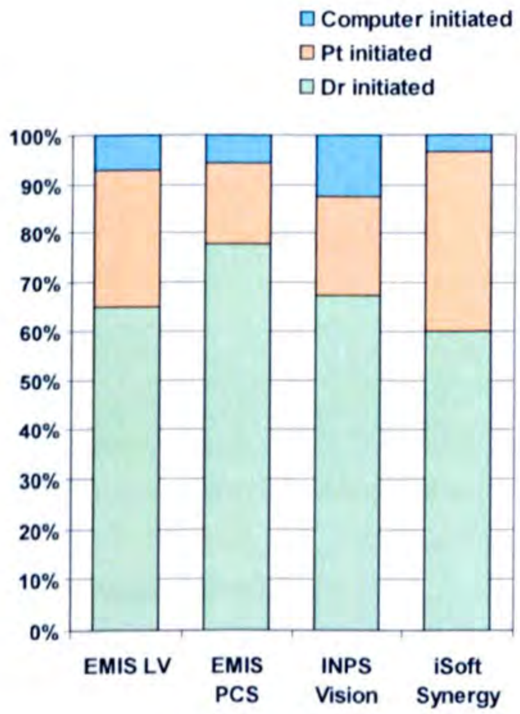


Figure 6.22: Proportion of consultations initiated by doctor, patient or computer, by EPR system

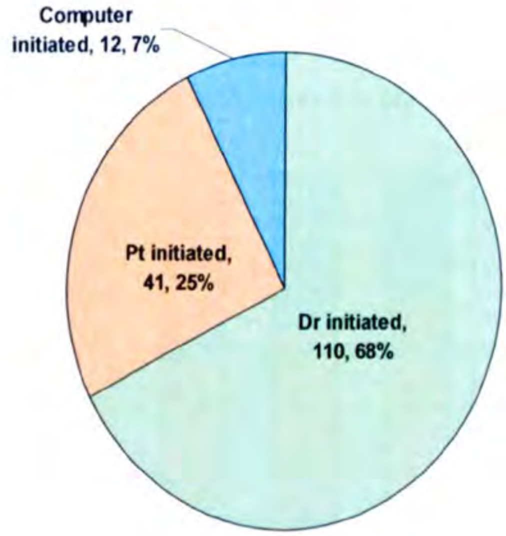


Figure 6.23: Proportion of consultations initiated by doctor, patient or computer

Patients were verbally interacting more in patient initiated consultations (p=0.49); this is 27.4% compared to 23.1% and 24.9% in doctor or computer initiated consultations respectively. Patients actively explained their concerns or expectations they have for the consultation, and doctors accommodated those, making related inquiries and referring to the EPR where needed. Computer initiated consultation appears to take longer; both doctor and patient initiated consultations have a mean duration of 11:42 minutes while computer initiation has resulted in a mean duration of 13:10 minutes. However this difference is not significant (p=0.6). In computer initiated situations, clinicians' actions often reflected the indications given by the EPR system, though in a rather opportunistic manner.

When prompts or reminders were presented by the EPR system, particularly if they contained additional messages than the usual patient summary, clinicians spent more time reviewing those. This was reflected by the increased use of computer during the initial-marginal consultation; largest proportion of computer use was visible in the computer-initiated category (mean=69.3%, SD=29.4%) while Dr-initiated has the next largest (mean=61.2%, SD=34.9%) with consultations of Pt-initiated type having the smallest proportion (mean=51.6%, SD=35.3%). Despite these differences in the use of computer before the core consultation, the overall computer use in the greater consultation remained un-affected (Pt-initiated: 47%, SD=14.3%, Dr-initiated: 47.8%, SD=14.2% and Computer initiated 48.7%, SD=17.0%, p=0.9). In average, three prompts (mean=3.17, SD=1.6) were noted in computer initiated consultation, whereas for the other categories of initiation this was two prompts per consultation (mean =2.17, SD=2.0 for Dr-initiated , mean=1.9, SD=2.0 for Pt-initiated).

Patients leading the initial doctor-patient verbal interactions, often prompted doctors to focus more on the past medical history or available latest test results. Doctors spent significantly longer (p=0.006) durations reviewing information available in the EPR; mean proportions for Dr-initiated and computer-initiated categories are 6.6% (SD=5.8%) and 5.5% (SD=4.1%) respectively, compared to 10.6% (SD=10.2%) for patient-initiated consultations. Consultation initiator did not influence the amount of data recording or the time spent on taking actions using the EPR system.

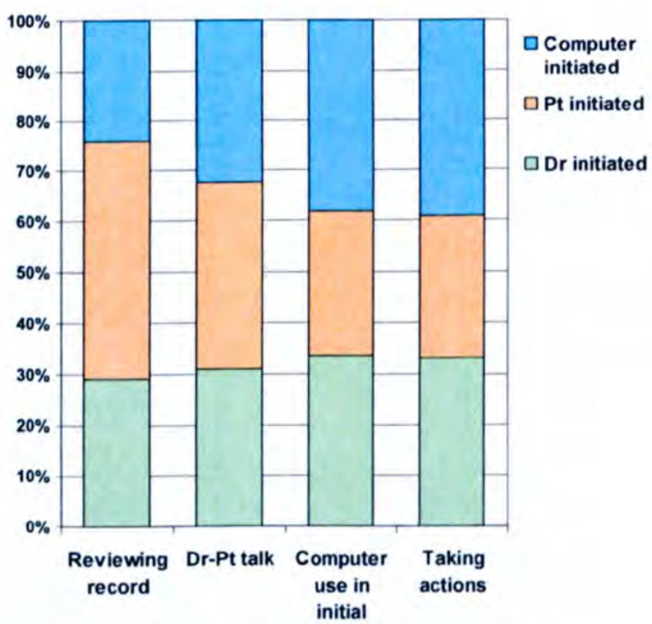


Figure 6.24: Changes to the doctor-patient-computer interaction proportions compared to the consultation initiator

	Proportions (t%)				Consultation count	
	ẋ	SD	X	IQR	Total N	N%
Reviewing of medical record						
All	7.6	7.3	5.8	8.7	163	100.0
Doctor initiated	6.6	5.9	4.8	8.4	110	67.5
Patient initiated	10.6	10.2	8.7	9.9	41	25.2
Computer initiated	5.5	4.1	4.6	6.2	12	7.4
Taking actions						
All	9.3	8.8	7.2	9.1	163	100.0
Doctor initiated	9.6	8.0	7.5	10.4	110	67.5
Patient initiated	8.0	7.9	7.3	8.2	41	25.2
Computer initiated	11.3	16.5	5.7	3.9	12	7.4
Computer use in initial-marginal						
All	59.3	34.8	68.9	57.3	150	92.0
Doctor initiated	61.2	34.9	73.6	55.9	100	61.3
Patient initiated	51.7	35.3	57.2	56.9	39	23.9
Computer initiated	69.3	29.4	79.2	42.9	11	6.7
Patient to doctor talk						
All	24.3	9.8	23.1	12.1	163	100.0
Doctor initiated	23.1	9.5	22.5	12.5	110	67.5
Patient initiated	27.4	10.5	25.7	13.0	41	25.2
Computer initiated	24.0	8.8	21.9	11.0	12	7.4

Table 6.6: Changes to the doctor-patient-computer interactions based on the consultation initiator

6.4 Consultation durations

The mean duration of a greater consultation is 11:49 minutes (SD=5:17 minutes, median = 11:07 minutes, IQR=6:22 minutes). It represents the length of time a doctor spends interacting with the EPR of a specific patient together with the actual doctor-patient contact time associated with a single encounter. Observed consultation durations are not normally distributed (D(163) = 0.08,p=0.008). The shortest observed duration is of 2:37 minutes while the longest is of more than half an hour (31:25 minutes). More than half (57%, n=93) of the consultations had a length between 7 to 14 minutes. There are eight consultations less than five minutes long (4.9%), all of which wee for routine medication reviews. Out of the nine consultations that were over 21 minutes, six (3.6%) were nearly half an hour long; they involved discussions about new problems and physical examinations away from the camera views.

There is no significant difference of consultation length associated with the EPR brand (p=0.1). Consultations recorded with PCS have the longest mean length (mean=13:25mins, SD=6:08mins) while shortest is observed with Vision (mean =10:29mins, SD=4:26mins). Doctor or Patient gender is also not significantly associated with the consultation duration (Dr gender p=0.1, Pt gender p=0.8). Nevertheless, consultations conducted by female doctors have a mean length nearly two minutes longer than those by their male colleagues (mean =13:02mins compared to 11:23mins). The mean durations of consultations with male and female patients are very similar; 11:51mins and 11:45mins respectively.

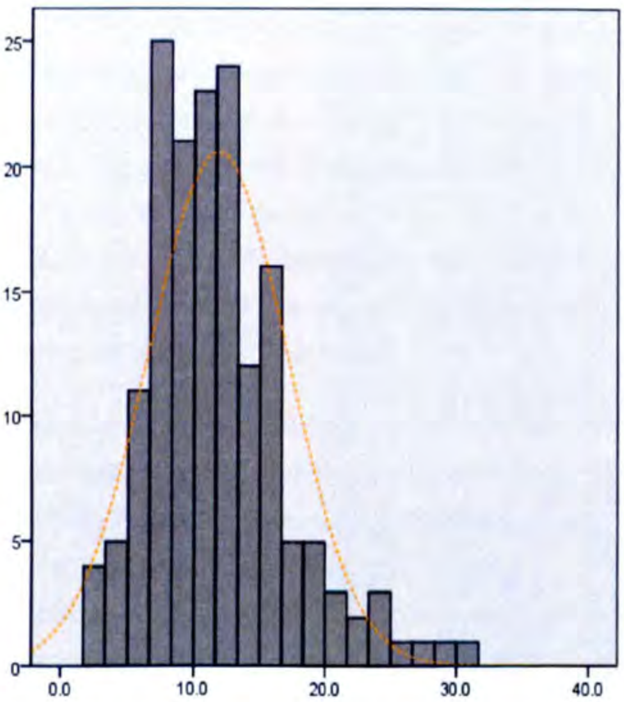


Figure 6.25: Distribution of consultation length within the study sample

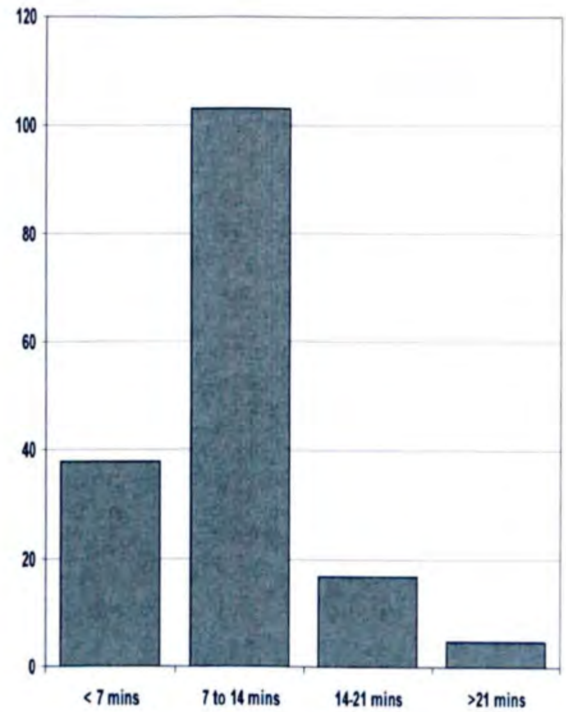


Figure 6.26: Number of consultations, by different bands of consultation durations

Consultations with patients older than 40 years are significantly longer (p=0.006) with a mean duration of 12:49mins, for younger patients this is 10:40mins. This could be partly influenced by the fact that, though both categories have similar amount of consultations where examinations are performed (younger;75.9%, older;76.2%) more consultations with older patients are interrupted (younger;30.3%, older;39.3%) and have occasions where doctor have left the room for various reasons (younger;22.7%, older;32.1%). Doctor's age does not have a significant association with the length of the consultations they conduct (p=0.3), however the number of years since their GMC registration does (p=0.03). Doctors who have been practicing for less than 10 years have a mean consultation duration of 10:43mins (SD=4:30mins), while for those with over ten years of experience the mean length is 12.30mins (SD=5:40mins).

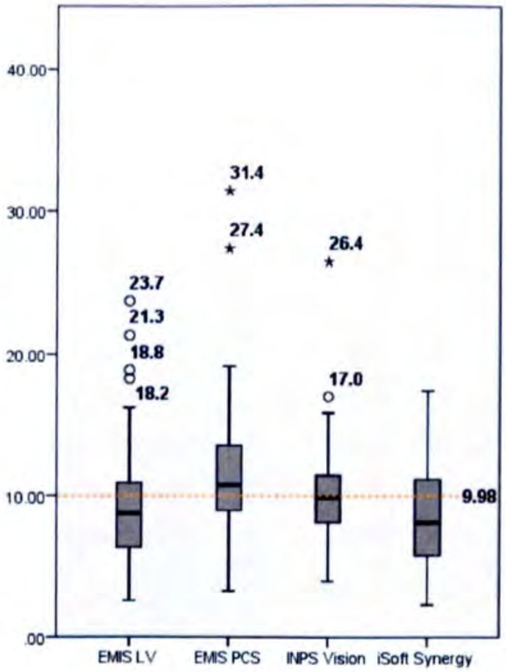
6.4.1 Un-interrupted consultation duration

The mean time taken for a consultation after excluding the durations associated with interruptions, examination and any periods where doctor is not in the consultation room is nearly 10 minutes (mean =9:59mins, SD=4:39mins, median=9:28mins, IQR=4:34mins). This remaining time also represents the period where doctor can potentially interact with the EPR system.

In contrast to the greater consultation time, the un-interrupted greater consultation shows a significant difference between the brand of EPR used (p=0.011); figure 6.27 and 6.28. Synergy has the shortest mean duration (mean=8:40 min, SD=3:43 mins) while PCS consultations are the longest (mean=11.49mins, SD=5:35mins). Consultations with Vision (mean=10:37min, SD=3:53 mins) and LV (mean=9:04 min, SD=4:35 mins) are shorter than PCS, and this difference is more than one and two minutes respectively. In fact the mean length of PCS consultations are significantly longer than LV and Synergy; p=0.005 for both comparisons.

In terms of the changes of the mean durations, its differences associated with doctor and patient characteristics are similar to those observed with greater consultation durations. No significant differences linked with the consulting doctor's gender (p=0.084), patients' gender (p=0.538) or doctor's age band (p=0.181) exist. The significant differences observed between the younger and older patients (p=0.008) still stands for the un-interrupted consultation length. Therefore, the significant differences between the two patient age groups, earlier suspected to be influenced by the un-related intermissions are not taken away even when the un-interrupted greater consultation lengths are compared. The two categories of doctors based on the number of years since GMC registration is also linked with differences in the un-interrupted consultation length (p=0.036).

There are five (3%) consultations that are over 20 minutes longer even when the un-interrupted consultation lengths are considered (figure 6.28). As a result the un-interrupted consultation length is also not normally distributed (D(163) = 0.12,p<0.001). Those five consultations are with female patients belonging to the over 40 years of age category, seen by female doctors, in two occasions patients were accompanied and involved activities related to creating test or referral requests, letter writing, looking up for information; there is nothing un-usual in the doctor-patient-computer interruptions simply other than the longer durations they have taken. Removal of these five consultation gives an apparently normally distributed un-interrupted consultation lengths when Kolmogorov-Smirnov statistics are considered (D(163) = 0.04,p=0.2) and with a mean duration of 9:47 minutes (SD=3.40mins).



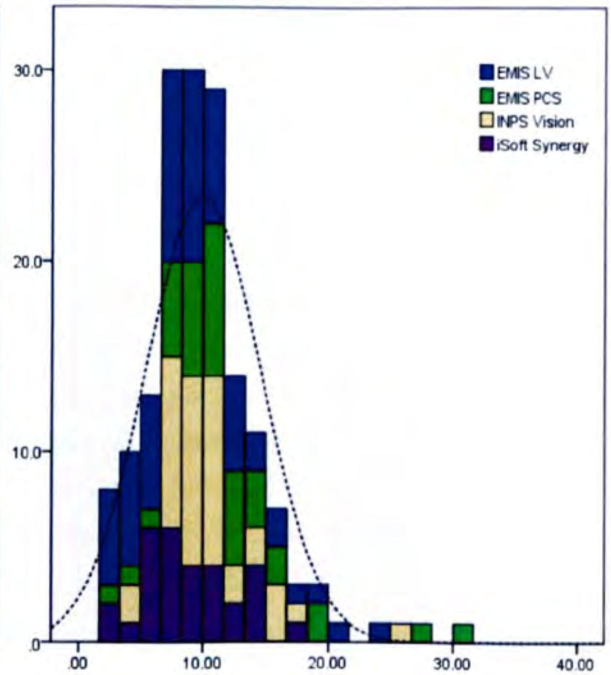


Figure 6.27: A box-plot representing the un-interrupted consultation durations by EPR systems

Figure 6.28: The distribution of the un-interrupted consultation durations and the associated EPR systems

Patients' age category	Consultations count	Physical examination		Incidents of doctor leaving the room		Interruptions	
	N	Absent	Present	Absent	Present	Absent	Present
< 40 years	79	24.1	75.9	69.6	30.4	77.2	22.8
> 40 years	84	23.8	76.2	60.7	39.3	67.9	32.1

Table 6.7: Association of patients' age category with incidents of examinations, doctor not in room and interruptions

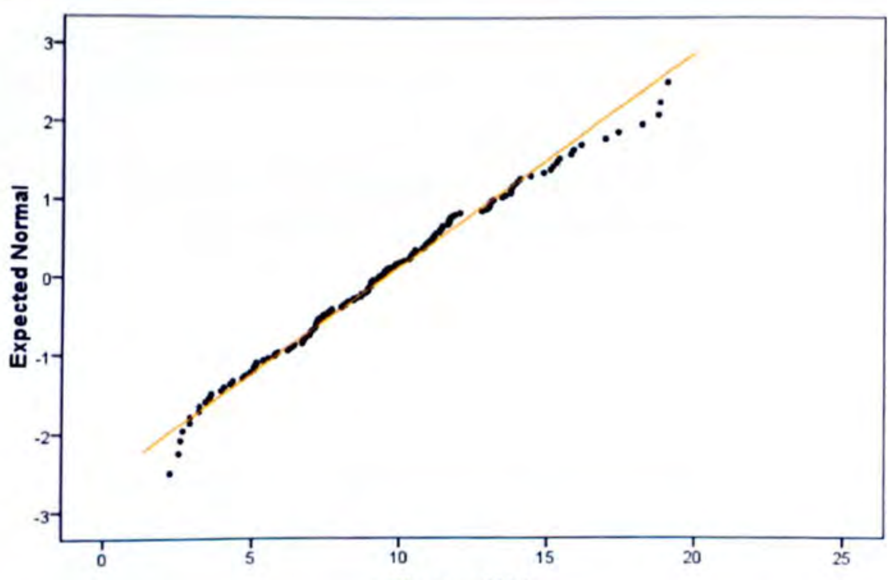


Figure 6.29: Q-Q plot of the un-interrupted greater consultation after removing consultations that are over 20 minutes long.

When un-interrupted duration is expressed as a proportion of the greater consultation, it has a mean value of 85.5% (SD=13.6%) with no significant difference associated with doctors' or patients' age-gender profiles. They are quite comparable between the EPR brands as well, with both PCS and Vision consultation having similar proportions (88.8% and 88.3%). LV has the lowest proportion with a mean value of 82% (SD=15.8%) with Synergy as next lowest (84.2%, SD=13.7%).

6.4.2 Global examination of the consultation time

The totality of the observed consultation duration involves tasks doctors do before, during and after the actual doctor-patient encounter time. This may also contain external constituents such as interruptions and consultation related tasks like physical examinations. Studying the distribution of the tasks based on the overall sample of video recorded consultations indicates the proportionate time they take and how prevalent they are.

The consultation starts with the initial-marginal consultation, during which the clinician reviews the records and calls the patient in; this represents nearly five percent of total recorded consultation footage (4.96%). The core consultation, the duration where patient is within the consultation room represents the majority of the observed time (87.6%). Clinicians take history, explore the problem, conduct examinations, formulate the treatment plan and agree on actions within the core consultation. Physical examinations took place in 124 consultations (76.1%) representing 12.3% of total recorded consultation time. As a result, 32.9% of the doctor-computer-patient interactions analysed in the overall sample are either from consultations with no physical examinations or based on observations prior to examination activities. The remaining 48.4% of the core consultation time represent interactions following examinations. In majority of consultations (n=145, 88.7%), doctors continued interacting with the EPR system after patient has left the room. These interactions in the final-marginal consultation, taking 7.42% of the recorded time were mainly aimed at completing the medical record entries or taking actions related to the continuality of care such as making referral requests. All phases of the consultation included interruptions. Nearly 7.7% of the initial and final marginal consultation durations were interrupted; while interruptions account for 1.3% of the observed core consultation duration.

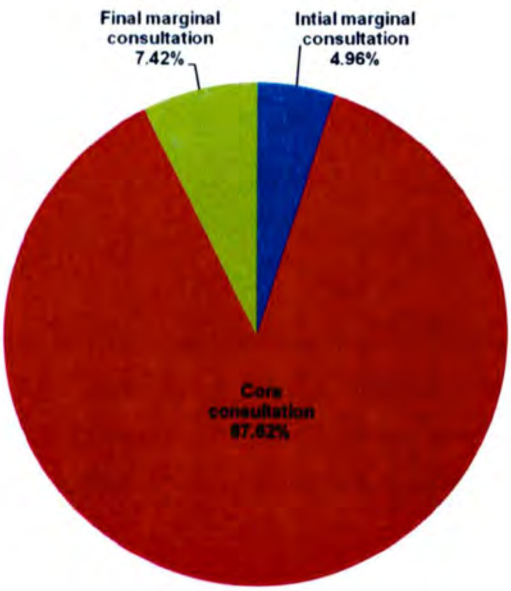


Figure 6.30: Distribution of the core and marginal consultation durations (in global sample)

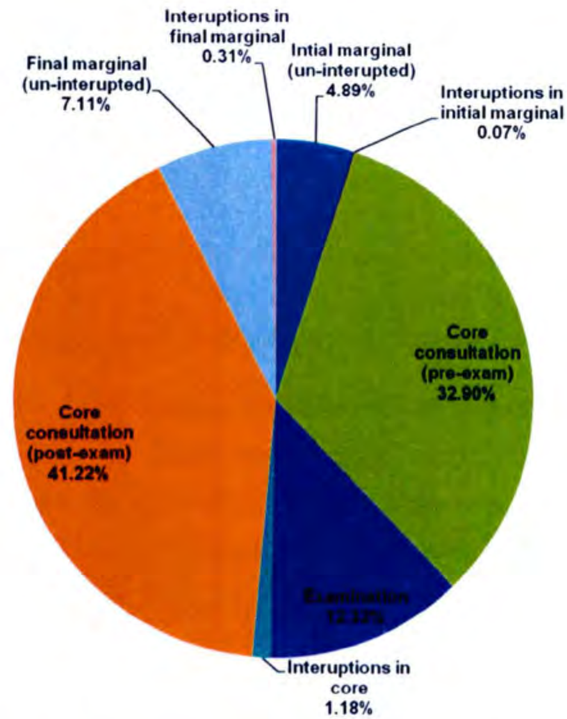


Figure 6.31: Distribution of the core and marginal consultations with interruptions and episodes of examinations (in global sample)

	Ttot%	X	SD	M	IQR	Min	Max	Ntot	Ntot%
Initial marginal (un-interrupted)	4.89	00:38	00:45	00:26	00:35	00:00	05:36	150	92.02
Interruptions in initial marginal	0.07	00:15	00:07	00:16	00:12	00:08	00:24	5	3.07
Core consultation (pre-exam)	32.90	03:53	03:29	02:53	04:51	00:24	22:39	163	100.00
Examination	12.32	01:27	01:55	00:58	01:47	00:00	11:47	124	76.07
Interruptions in core	1.18	00:34	00:28	00:24	00:22	00:06	02:12	40	24.54
Core consultation (post-exam)	41.22	06:24	03:42	05:45	04:08	01:08	21:09	124	76.07
Final marginal (un-interrupted)	7.11	00:57	01:15	00:28	01:18	00:00	08:14	145	88.96
Interruptions in final marginal	0.31	00:45	01:04	00:20	00:41	00:03	03:13	8	4.91

Table 6.8: Components of the consultation length; as a proportion of greater consultation and other statistics

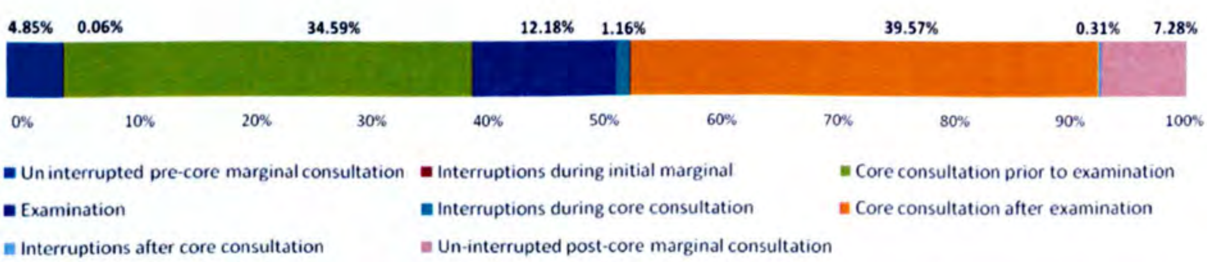


Figure 6.32: Proportions of the core and marginal consultations with interruptions and episodes of examinations (in the global sample)

6.5 Durations and content of core and marginal consultations

6.5.1 Initial-marginal consultation

Except in situations where a patient is already in the consultation room, having arrived as a family member accompanying the previously seen patient (n=4), doctors always selected and loaded the EPR before inviting the patient in. These initial-consultation periods are visible in 150 of the consultations (92%), with a mean duration of 38 seconds (SD=46s, median=26s, IQR=34s). This could not be rated in seven consultations, due to technical reasons. When compared between EPR systems, the minimum reported occurrence was from Vision (n=35/40, 87.50%), more than 90% of the consultations with all other systems had this initial-marginal period.

After selecting the patient from the appointment list, doctors reviewed the past encounter summaries for the patients together with any test results or letter from received from external health care professionals. PCS usually provides a prompt with the essential summary before taking the user to the main consultation view. In other systems, prompts or reminders are displayed on per item basis rather than as a summary. In Synergy, this reminder mechanism is part of the default consultation view rather than of the initiation process.

In addition to the information reviewing, this part of the consultation also included preparation tasks such as arranging the patient's chairs (n=11/150,7.3%), organising the desk (n=8/150,5.3%), examination areas (n=11/150, 7.3%) and adjusting the computer screen (n=3/150,2%). Inviting the patient in using any of the three approaches introduced earlier, marks the end of planned preparation activities doctors do during the initial-marginal period. In situations where doctors do not leave the room to call patients in, doctors continue visually scanning the EPR content, though mostly on random basis. The proportion of initial marginal consultation is largest in LV consultations (7.42%), this is significant when compared with that of Synergy (4.37%, p=0.036) with a mean value of 50 seconds (SD=58s). Remaining three systems have a mean length of 35 seconds or shorter. Proportionately, all LV users seem to spend about 7.4% of the consultation time before inviting the patient in, while for other system users this is less than 4%. Interruptions occurred in five initial-marginal consultations (3.3%) with a mean duration of 15 seconds (SD=7s); two of these involved doctor having to leave the room.

6.5.2 Core consultation

The proportion of the consultation where clinician engages in consultation tasks while a patient is present has a mean duration of 10:21mins (SD=4:43mins, median-9:51mins, IQR=6:06mins). This has a mean proportion of 87.5% (SD=9.4%). Mean proportion value of core consultation is largest in those observed with Synergy systems (88.1%, SD=8.9%), with values decreasing in the Vision, then PCS and LV in the lowest end with a mean proportion of 85.9% (SD=9.4%). These proportions are relatively similar amongst the doctors using each of the systems except in LV consultations. Amongst the users of PCS, Vision and Synergy consultations mean core values having the maximum difference of 5.5% between the largest and the smallest. When Consultations with five LV users are considered the minimum and maximum proportion of the core consultation are 79.4% and 94.4% respectively.

Examinations occurred in nearly three quarter of the consultations (n=120/163, 73.6%). There are a total of 164 examination related interactions. There are 71 consultations with a single episode of examination, while 71 had multiple occurrences. There are 43 examinations that were carried out away from the camera view. Examinations that did not involve undressing occurred in the camera views (n=79). Quarter of the recorded consultations are for checking patient's blood pressure (n=42/160, 25.7%). In one occasion, a doctor carried out the examination after closing the camera lenses with the lens cap. When patients were examined on the examination couch, doctors continued interacting with the computer on six occasions until patients were ready, while there were two instances where doctor left the room to get some apparatus needed for the examination. Both those are pregnancy related examinations. The mean length of the recorded examination durations is 1:27 (SD=1:55mins, median=58s, IQR=1:47mins). Time spent examining patients are similar in consultations with all four EPR systems with mean durations ranging from 1:12mins to 1:42mins. Proportion of the time doctors examined patient is 11.3% (SD=11.9%) of the greater consultation.

Nearly a quarter of the consultations (n=40/163, 24.5%) had interruptions occurring within the core consultation, where patient was still in the room. The mean length of an interruption in core-consultation is 34 seconds, representing about 5% (4.9%, SD=3.5%) of the greater consultation. Maximum reported was 2:12 minutes long which was due to colleague coming to see the consulting doctor seeking advice. Out of the 40 observed interactions, 17 (42.5%) are related to the consenting process where patients decided to fill the remaining sections of the consent form. In six occasions (15%), doctor left the room as a result of the interruption. There were 14 other instances where the doctor left the room during the core consultation for tasks related to the ongoing consultation.

6.5.3 Final marginal consultation

After patients have left the room, doctors completed the new additions done to the EPR and exit from the main consultation window to see the appointment list. At most, closing of the EPR is performed in 145 (89%) of the successfully rated final-marginal consultations. In majority of instances doctors continued with their data entry tasks in this period. There were twelve occasions where this portion of the consultation was spent on dictating referral letters. Doctors also performed certain housekeeping tasks such as clearing the examination area if the examination bed was used and washing hands in preparation for the next consultation. The proportion of the final-marginal consultation is about 8% (SD=8.2%) of the greater consultation. It is nearly a minute long in the study sample (mean=59s, SD=1:18mins, median=28s, IQR=1:19mins). Interruptions occurred in eight consultations (439%) during the final-marginal period, taking a mean duration of 45 seconds (SD=1:04mins). Two if those interruptions resulted in doctor leaving the room.

6.6 Doctor – Computer – Patient interactions in the greater consultation

Doctor-computer interactions take place in marginal and core parts of the consultation, while during the core consultation they continue mutually with doctor-patient interactions, and often overlap. The computer use interactions related to problem discovery, decision making and treatment planning are closely associated with doctor-patient interactions; there are clearly visible sequences of question-answer cycles between the doctor and the patient running in parallel to the doctor-computer interactions. Data entry or information reviewing tasks doctors do using the EPR system are often complemented by verbal and non-verbal interactions between doctor and patient. When the overall video footages from all consultations are concerned, doctors engaged in computer use with no interactions with patients for quarter of the consultation (24.78%); this is approximately three minutes (mean=2:56mins, SD=1:44mins). There is another 15% of the consultation time where doctors interact with the computer while interacting with their patients. When the overall mean proportions of the individual consultations are considered, this 15% consists of a 2% proportion (mean=2.15, SD=1.83%) where doctor and patient verbally communicate, look at eachother even though doctor is still continuing with the computer use, and another 3% (mean=12.96%, SD=8.39%) where no eye contact is made. Computer use and doctor-patient interactions often overlap when doctor is entering free text, recording blood pressure measurements and prescribing; sometimes they were resulted by inquiries patients made. There were also instances where doctor decided to comment related to the ongoing actions.

There is an important share of the core consultation dedicated to direct doctor-patient interactions; where the doctor assigned his or her complete attention to the patient, physically turning away from the computer screen. This is about 45% of the greater consultation (mean=44.27%, SD=13.85%), representing about five and half minutes (mean=5:25mins, SD=3:28). As discussed previously, examinations take about 12% of the consultation length (mean=11.26%, SD=11.90%). About 3% of the consultation did not contain any specific interactions rated for this study; this mostly contained activities doctor spent tidying the consultation room, preparing for examinations and unrelated paper work, gaps in doctor-patient interactions or time patient took to settle in or getting ready to leave.

The proportions of verbal interactions doctor or patient initiated during doctor's computer use are almost equivalent. About 1% (mean=1.19%, SD=1.1%) of the verbal interactions with eye contact, and 6% (mean=6.24%,SD=5.08%) of the talking without eye contact that took place during the computer use were initiated by doctor, and similar proportions were initiated by patient (mean=0.96%, SD=0.90% and mean=5.98%, SD=4.91%).

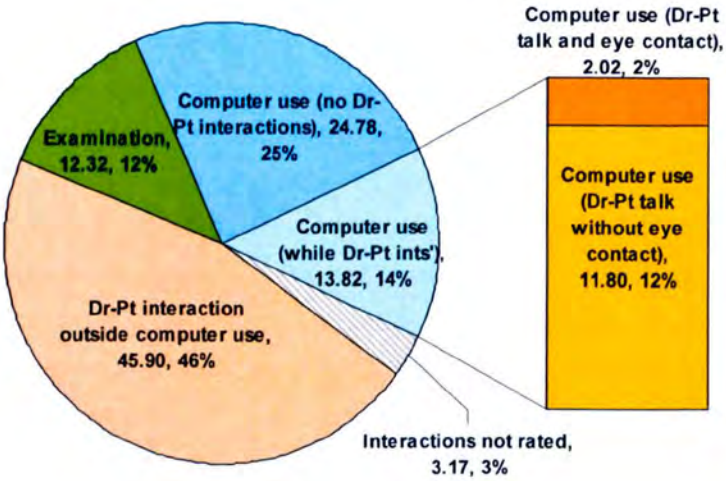


Figure 6.33: Doctor-patient-computer interactions in greater consultation: Computer use, Doctor-patient interactions during and outside computer use

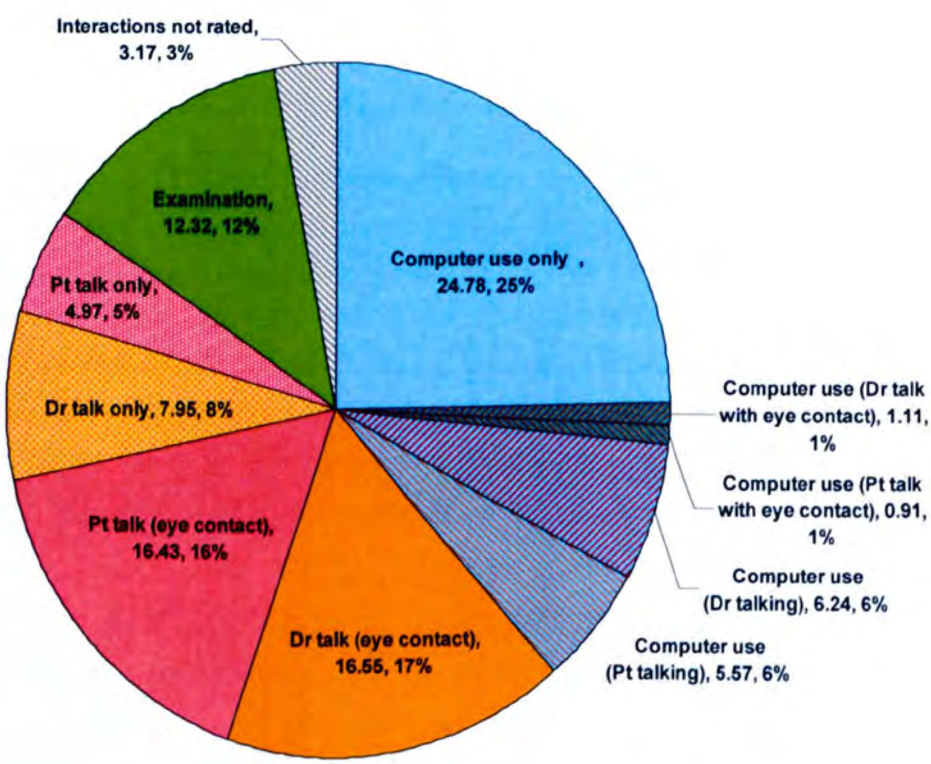


Figure 6.34: Doctor-patient-computer interactions in greater consultation: detailed breakdown of computer use, Doctor-Patient interaction with or without eye-contact, during and outside computer use

Doctors and patients equally dominated the doctor-patient interactions outside computer use. Doctor talking to patient, while maintaining eye contact was 16% (mean=16.04%, SD=8.64%) based on the proportionate durations from each consultation. Patient initiated talk also had a similar mean duration (mean=15.73%,SD=8.64%). Doctor initiated the majority of verbal interactions without eye contact, about 8% (mean=7.75%, SD=4.67%) of the consultation time whereas patient did so only 5% of the time (mean=4.78%,SD=3.23%).

6.6.1 Overall computer use in greater consultation

Despite the considerable heterogeneity of computer use observed between systems, clinicians appear to devote a consistent proportion for carrying out routine tasks using their EPR systems. Doctors spent around 40% of the entire consultation, interacting with the EPR system (mean=40.6%, SD=13.8%, median=41.3%, IQR=19.8%). This represents 4:35 minutes (SD=2:21mins) of an average length consultation. Computer use is normally distributed across the study sample (D(163)=0.048, p=0.2). The proportion of computer use in the greater consultation after excluding the episodes of examination and interruption is 47.7% (SD=14.4 %). This is also fairly normally distributed (D(163) = 0.06,p=0.2).

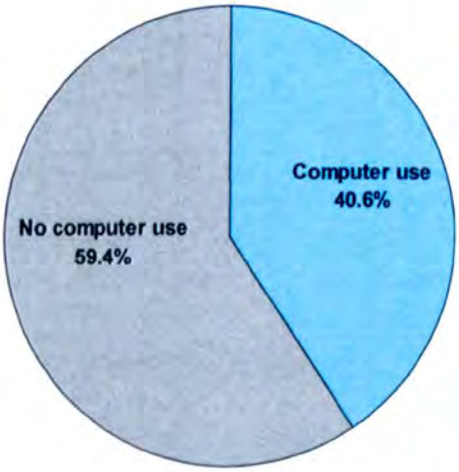


Figure 6.35: Computer use proportion within a consultation

There is no significant differences between the EPR brands when the proportions of computer use from greater consultation are concerned (p=0.122). Consultations recorded with Vision have the largest proportion of computer use while those with PCS have the smallest, they are 44.6% (SD=11.7%) and 37.3% (SD=11.8%) respectively. Both those EPR systems have graphical interfaces. Consultations with LV, which is the only character based EPR system recorded in this study have a computer use proportion slightly higher than the sample mean (40.7%, SD=15.6%). Synergy has the second smallest computer use proportion with a mean value of 39.2% (SD=14.1%). The minimum computer use proportions reported from all systems except from Vision are around 12%, the smallest proportion recorded from a Vision consultation is 18%. Both LV and Vision systems have been used in situations where doctor-computer interactions have taken up to three quarter of the consultations (75.7% and 74.6% respectively), whereas maximum rated from Synergy is 64.5%. A PCS consultation with 59.2% of computer use is the maximum for that type of EPR system, also making it as the system with the shortest range of computer use proportions.

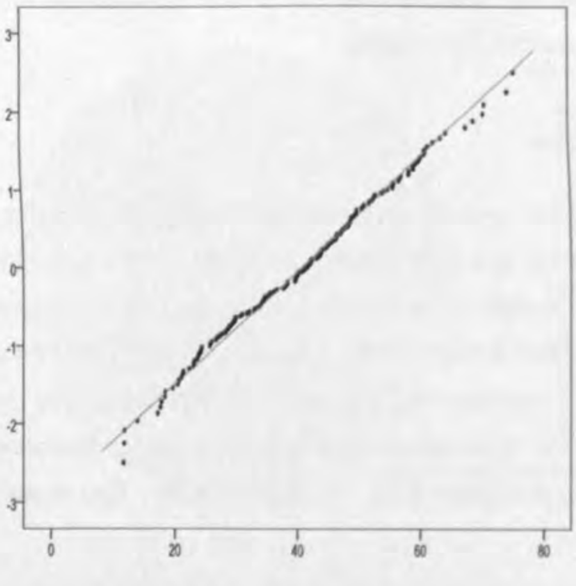


Figure 6.36: A Q-Q plot representing the distribution of the computer use proportion

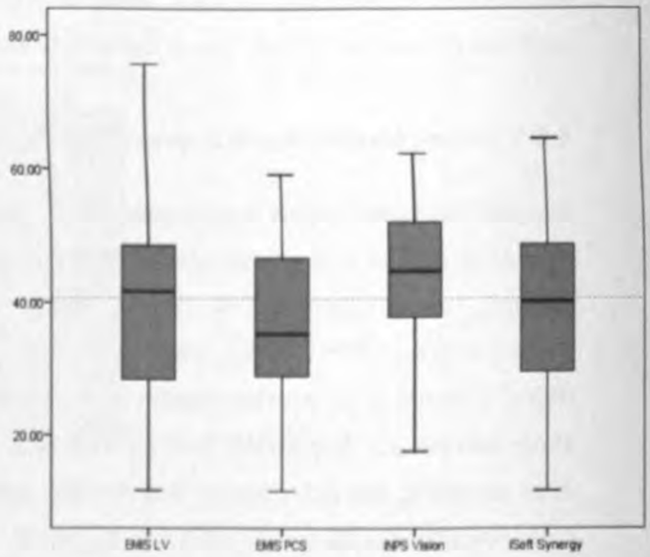


Figure 6.37: A Box-plot plot representing the distribution of the computer use proportion across the four EPR systems

	Doctor gender		Doctor age in 40 years band		GMC registered years		Patient gender		Patient age in 40 years band	
	Male	Female	< 40	> 40	< 10	> 10	Male	Female	< 40	> 40
Mean	41.8%	37.2%	40.1%	41.7%	39.6%	42.2%	37.7%	42.4%	40.1%	41.2%
SD	14.3%	11.6%	13.9%	13.5%	13.7%	13.8%	13.7%	13.6%	14.3%	13.3%
ANOVA p		P=0.061		P=0.492		P=0.230		P=0.038		P=0.669

Table 6.9: Variations of the computer use proportions associated with doctor and patient characteristics

The amount of computer use appears to be not significantly influenced by the doctor's age, gender or number of years they have been practicing as a GP. Female doctors use computers less compared to male doctors, nevertheless this difference is not significant (p=0.061). Doctors who are over forty years of age, or those with more than ten years of GMC registration also interacted more with the EPR system than the doctors belonging to opposite categories, neither of those differences are significant (p=0.492 and p=0.230 respectively). Consultations with older or female patients also had higher proportions of computer use compared to those with younger or male patients. While patient age category is not a considerable influence (p=0.669), patient gender seems to have causes a significant difference in the computer use proportions (p=0.038). The mean length of the computer use is in fact only ten seconds different when the consultations with male and female patients are considered. The significance difference in the proportionate time of computer use is actually associated with the nearly two minute gap observed between the average length of a consultation with female and male patients (female patients 4:43/13:02mins, male patients 4:32/11:23mins).

6.6.2 Predictors for computer use – multiple regression analysis

Following the stepwise removal of the potential predictors, the regression analysis in fact proposed a poorly-fit model (R2 adj= 22.5%, p<0.001), nevertheless with six significant predictors for the proportion of computer use. Two of these are dummy variables representing the EPR brand. It was found that female doctors (â=-6.235, p<0.05), presence of extra persons accompanying the patient (â=-8.73, p<0.01) and having EMIS-PCS as the EPR system (â=-7.25, p<0.05) are significant predictors, and result in decreasing the proportion of computer use. The three other remaining significant predictors suggested by the model, patient gender (â=-3.77, p=0.88), prescribing tasks (â=4.58, p=0.05) and Vision EPR brand (â=6.38, p<0.05) are associated with increased use of the computer.

Variable	**B (SE)**	**â**	***t test*(*p* value)**
Selected variables (R = 0.475, adjusted R^2 = 0.225)			
Dr gender - female	-10.85(2.69)	-.321	-4.069(<.001)
Pt gender - female	3.77(2.67)	.121	1.717 (.088)
Pt accompanied by extra person/s	-8.86(2.40)	-.260	-3.686(<.001)
Prescribing present	4.58(2.34)	.140	1.959(.052)
EPR brand – PCS*	-7.25(2.78)	-.199	-2.609(.010)
EPR brand – Vision*	6.38(2.66)	.184	2.394(.018)
Removed variables			
Pt age	0.22 (2.36)	-.004	-057(.954)
Dr leaves room to call in the Pt	-1.44(3.20)	-.049	-.620(.536)
EPR brand – Synergy*	-1.87(3.09)	-.041	-.507(.613)
Room layout – Dr controlled	-2.53(2.44)	-.001	-.015(.988)
Dr age	-3.13(2.65)	-.096	-1.180(.240)

* Entered as dummy variables with EMIS LV as the baseline

Table 6.10: Variation of computer use proportions in greater consultation compared to possible predictors; outcome of multiple regression analysis using backward stepwise removal of variables.

6.6.3 Distribution of the computer use in consultation components

More than half of the initial consultation and almost three quarters of the final marginal consultation is spent using the computer; these are 59.3% (SD=34.8%) and 74.6%(SD=35.3% respectively. In the majority of consultations computers were used in both initial and final marginal periods (n=129/163, 79.1%), while in the remaining consultations (20.9%) doctors used only one of those marginal periods for computer use. Computer use is always evident in the core-consultation. Doctor-computer interactions occurred for 35% (SD=15.6) of the core-consultation duration. Most of the time before the core consultation is used for reviewing past medical history; the time after is spent writing up the record.

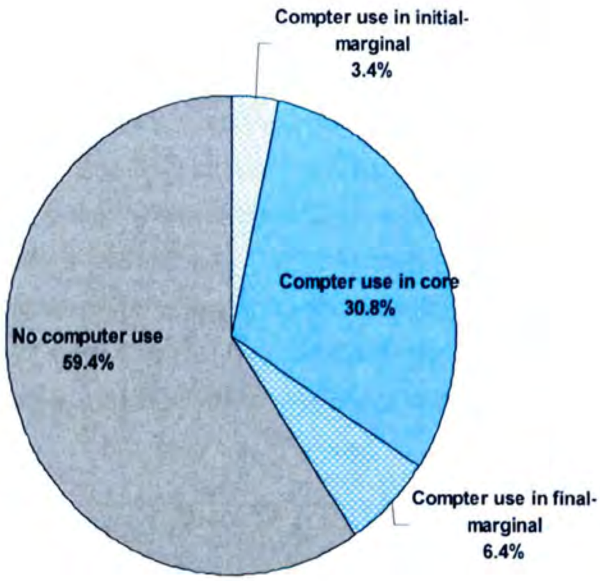


Figure 6.38: Distribution of computer use across the components of the consultation duration

6.6.4 Computer use tasks

Doctors-computer use is primarily split between tasks for reviewing information in medical record, making new record entries and taking actions associated with consultation outcomes. When measured as a proportion of the computer use duration, doctors spend just over a third of the time on (37%) viewing the information without doing any changes to the EPR, more than half of that (21%) is looking at the normal consultation interface without focusing on or interacting with a specific area of the interface. The remaining component of the duration doctors spend looking at the screen represents the time they purposefully review the past encounter details. Half of the computer use time represents doctors actions aimed at recording data into the EPR (31%) and using the system to take actions associated with the consultation outcomes (19%).

In an average length consultation, doctors spend about 45 seconds (SD=40s) reviewing information, one and half minutes (mean-1:28mins, SD=54s) recording data and another minute (SD=1:12mins) using the systems to take actions as they come upon during the consultation. They also spend about a minute (mean=57s, SD=1:27mins) looking at the default consultation interface, going over the variety of information presented, while another half a minute (mean=37s, SD=31s) is spent for moving between different areas of the screen, responding to prompts system presents or dealing with system errors.

Episodes of doctor looking at the default consultation screen, studying the EPR overview and overhead activities were recorded in all consultations. Data recording happened in all but six consultations, while information reviewing by scanning the past encounter data occurred in 92% (150/163) and actions were taken in 85% (139/163) consultations.

The proportion of the consultation time doctors spend reviewing the information is influenced by the brand of EPR system they use (p=0.018), however not by the doctor or patient characteristics. PCS users have the smallest episodes of information reviewing (mean=5.4%, SD=4.3%), while LV and Vision users spend very similar period of time (6.9% and 6.4% respectively). Synergy consultations have the largest proportions of greater consultation time allocated for record reviewing (mean=10.3%, SD=8.8%). There are no clear differences in the time spent on information reviewing linked with the doctors' gender, age or GMC years categories and for patient age and gender categories (p>0.1 for all). However, consultations with older doctors and those involving female or over 40 years old patients have longer proportions of record reviewing.

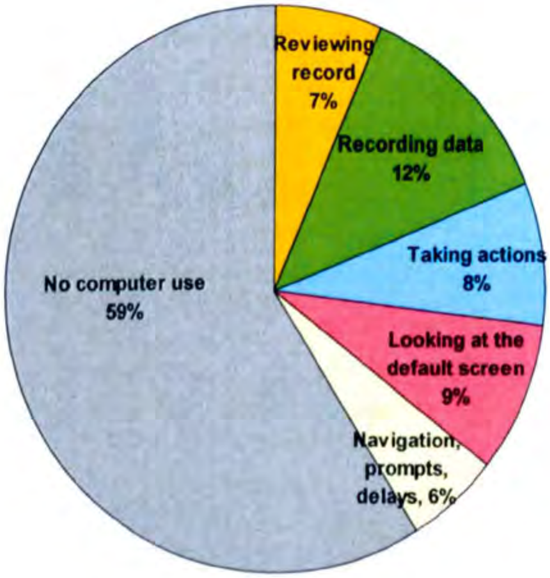


Figure 6.39: Proportions of different computer use tasks within the greater consultation

Figure 6.40: Different computer use tasks as proportions of the computer use duration

The type of EPR system used has a significant influence on the time doctors spend for recording data (p=0.020). Vision and Synergy, both of which are GUI systems with two or more sub windows with tab separated pages, have the largest and smallest proportions respectively for the consultation time allocated for data recording (mean=14.5%, SD=6.2 and mean=9.7%, SD=5.6%). LV and PCS users also spend more than 10% of the consultation time for data recording (PCS;mean=13.2%, SD=6.5%, LV;mean=13.0%,SD=5.6%). There are no significant differences associated with the doctor or patient profiles (p>0.1 for all). Male doctors appear to spend more time on data recording compared to female doctors (12.9% compared to 11.2%), otherwise data recording times are very similar between doctor and patient categories; proportionately their differences are less than 1%.

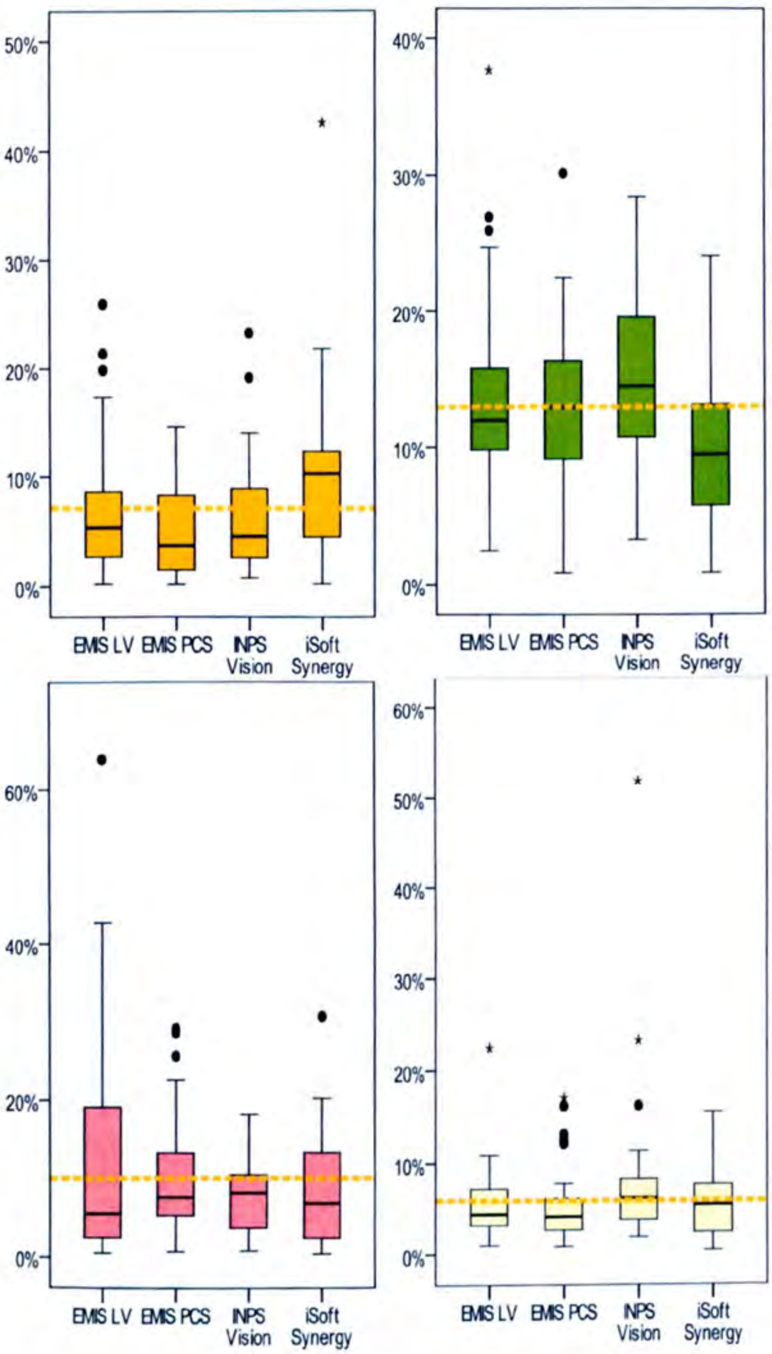


Figure 6.41: Box-plots representing the proportion of computer use durations allocated for different tasks; clock-wise – reviewing record, recording data, taking actions, overheads and looking at the default screen.

Proportion of computer use time allocated for taking actions, which include prescribing tasks and activities such as writing referral letters takes about 8% of the greater consultation. Those tasks represent 6% to 10% of the greater consultation length depending on the EPR system used. PCS has the smallest proportions (mean=7.9%, SD=5.8%) while Vision consultations have the largest (mean=10.9%, SD=8.1%). Those differences are not significant (p=0.23). Amount of time doctors spent looking at the default consultation interface, without doing any specific interaction is largest in LV consultation, which is a character based system (mean= 12.1%,SD=14.1%). All other system users have spent less than 10% of the greater consultation looking at the screen without focusing on a specific task, with Vision having the smallest proportion (mean=8%, SD=4.6%). Doctors that belong to the over 40 years of age category spent more than twice the amount of time looking at the default consultation view without performing a specific activity (<40 years; mean=6.6% SD=12.4%, >40 years; mean=12.9%, SD=14%), this difference between the age bands is significant (p=0.005).

Except in the consultations with Vision EPR system, all others have about 5% of the consultation time taken up by navigation related activities or by tasks for responding to system generated prompts and errors. Vision users have spent about 7.7% (SD=8.3%) of the consultation time on those overhead activities. Amongst the GUI systems, Vision has the most number of navigation mechanisms presented in a single window, doctors specially find the hierarchical tree structure that presents the patients summary difficult to interact with. There are no any other aspects of screen use or system overhead durations significantly influenced by doctor or patient characteristics.

6.7 Common computer use tasks – detailed view

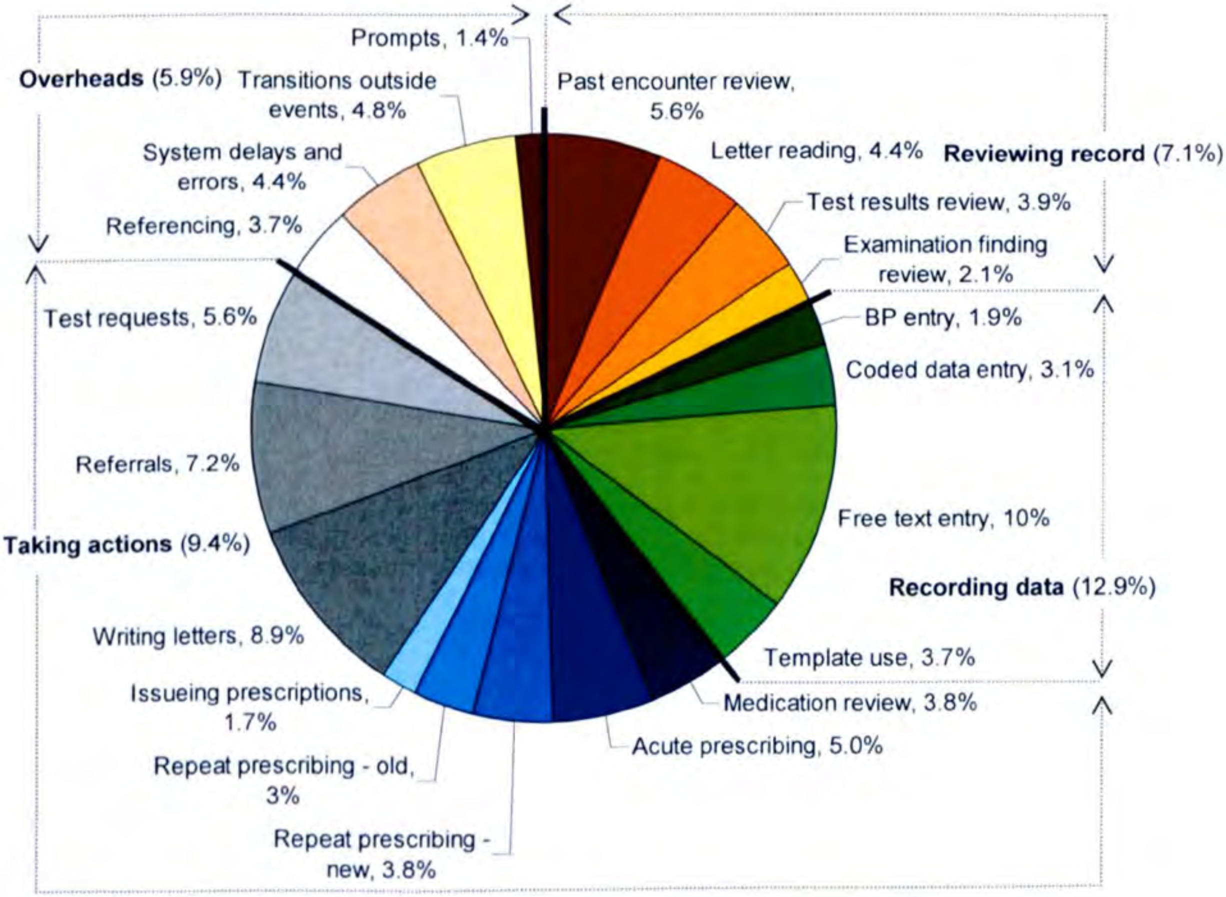


Figure 6.42: Distribution of computer use durations associated with common consultation tasks, shown as proportions of the greater consultation duration. *(Percentage values shown are based on the actual number of consultations in which the particular task was observed. Therefore the sum of proportions is less than 100%, approximate proportionate values are used to make the pie chart complete)*

Common consultation tasks reflecting all three key aspects of doctor-computer interactions occurred in nearly 80% of the consultations (n=127/163). Out of the remaining doctor-patient encounters, a combination of two categories of computer use tasks took place in 31 occasions (19%), and a single type of activity in three instances (1.8%), while none occurred in two consultations (1.2%). In those two consultations where no key task type took place, doctors looked at the default consultation view to have an overview understanding of the patient's medical record without interacting with a specific functional area. Both those consultations were conducted using PCS. Within the consultations where only two key types of consultation tasks were performed, majority had information reviewing and data recording type tasks (n=19/31,61.3%). There were two consultations where doctor decided to enter coded and free text data straight after a period of discussion with the patient. Thirteen consultations where no reviewing of information occurred represent all four EPR system types and are not specific to a particular doctor or patient characteristic.

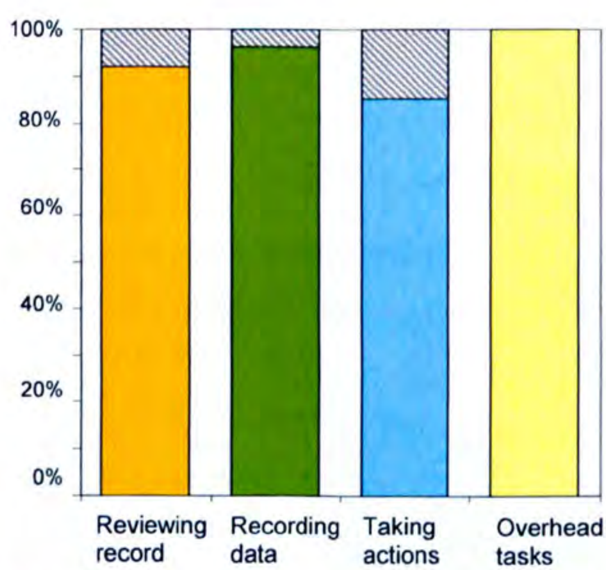


Figure 6.43: Proportions of consultations with the three key consultation task categories, and the presence of overheads in the study sample.

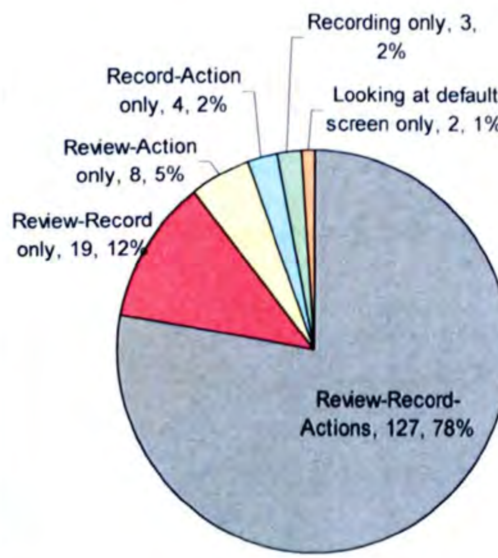


Figure 6.44: Occurrence of the three main consultation task categories in different combinations.

6.7.1 Reviewing patient's medical record

When doctors used the EPR interface to review patient's medical history, they mostly did so by going through the summarised or detailed medical record entries. Doctors performed those information reviewing activities primarily in preparation for the consultation. Reviewing the past encounter summaries, where objectives and outcomes of previous consultations with the patient are recorded, together with any outcomes of encounters with other health care professionals or conclusions of test results and examination findings are the most recurrent medical history reviewing activities observed. This could be seen in all consultations (150/163, 92%) that were categorised has having a medical record reviewing interaction. In those consultations, doctors spent about half a minute (mean=34s, SD=27s) going through the past encounter summaries, allocating 5.6% (SD=5.1%) of the total consultation duration.

Doctors used the chronologically ordered past encounter summary list in more than 70% of patient medical history reviewing interactions. These summary lists covered the key data elements entered during each doctor-patient encounter, together with examination findings and any medications prescribed. However the way in which this information is presented and structured varies between systems. The next largest proportion of encounter reviewing type interactions (24%) is focused on the default consultation interface, which usually presents a summary of patient medical history, focusing more on the data items rather than the encounter episodes. This default view requires additional interactions if doctor wishes to explore a particular area of medical history, and does not contain any narrative data. The medical record summary views used in 15 occasions only had a list of problems, symptoms and key life style data.

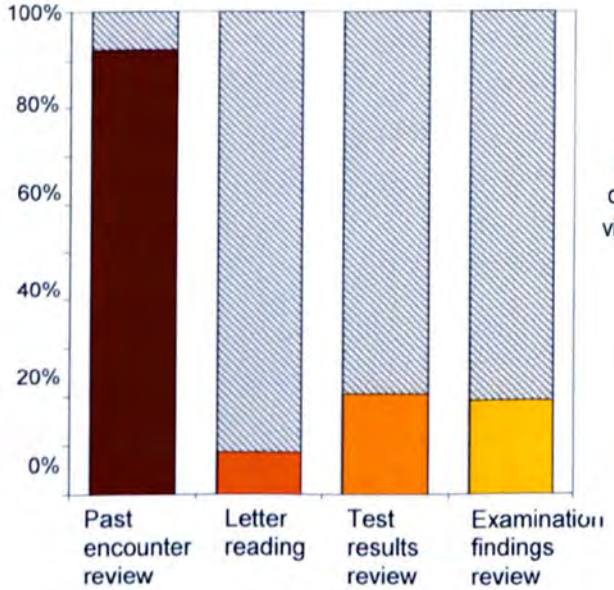


Figure 6.45: Proportions of consultations with the four different types of patient history reviewing tasks.

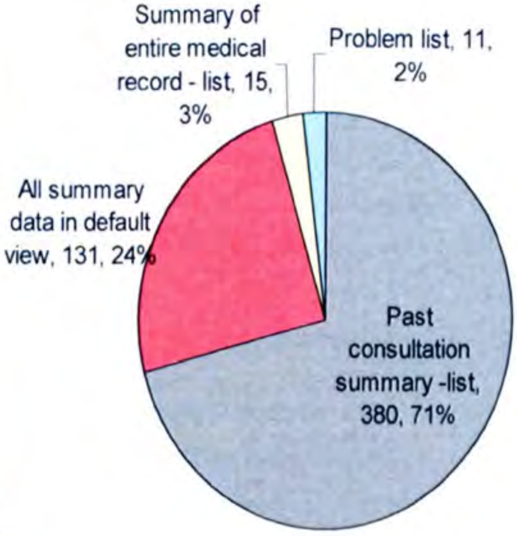
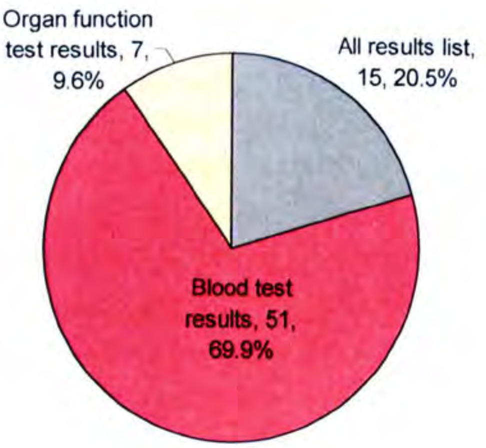


Figure 6.46: Different approaches used for reviewing the past medical history data, and proportions based on their total number of occurrences.



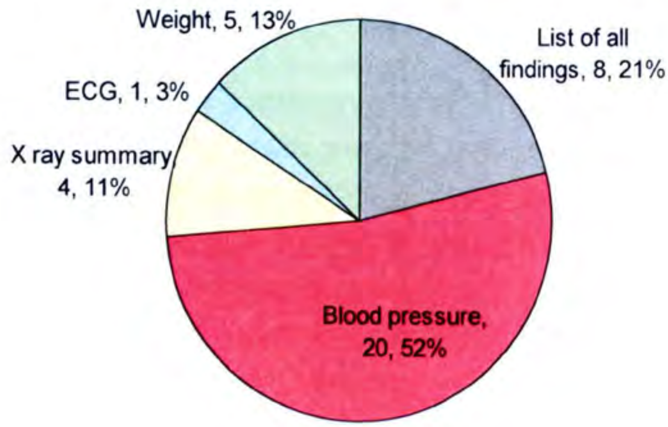


Figure 6.47: Proportions of test result types reviewed.

Figure 6.48: Proportions of examination finding types reviewed.

In about one fifth of the study sample (n=31/163, 19%), doctors went thorough the test results recorded in the EPR. This was mostly done as an extension to the encounter reviewing activity, however using a different data presentation area. This also took about half a minute (mean=30s, SD=28s). Reviewing and reflecting on the blood test results is the most frequent, associated with nearly 70% of the test results reviewing actions. When doctors requested for results from all types of tests, EPR systems usually provide a chronological ordered list, where further filtering can be done based on a particular test type.

In similar proportion of consultations (n=33/163, 20.2%) doctors examined various letters received from other health care professionals, mostly from secondary care. They are available in the EPR as digitised documents; scanned in paper letters. On average, doctors spent about half a minute (mean=34s, SD=33s) going through those letters, and in two occasions this took more than a minute (1:24mins and 2:49mins), both of which involved reading through multiple letters.

Reviewing the findings from previous examinations is another activity doctors performed to support the ongoing consultation, in the majority of the instances past blood pressure or BMI recordings has been the focus. Doctors spent in average 17 seconds (SD=19s) going through the examination outcomes in 14 consultations (8.6%). On the two occasions doctors explored the changes of the blood pressure measurement using graphical representations, where series of values are plotted against a time line. Both X-ray summary and ECG results were available as scanned documents.

6.7.2 Recording data into the medical record

Recording of data into the EPR, which is the most prominent doctor-patient interaction representing about one third of the computer use time (31%), largely consists of coded and free text data entry tasks. Free text entry occurred in a vast majority of the consultations (n=152/163,93%) and most of the time they were accompanied by at least a single coded entry (n=136/163, 83.4%).

Doctors articulated the main topics discussed during the consultation into narrative free text data, taking about 12% of the total consultation time (SD=7.1%). In average this is about one minute of the consultation (SD=50s). If entered while patient is present, free text entry was often done in an episodic manner, doing a single sentence at a time. There were two main approaches of free text entering noticed in the study. One approach involve structured entry of data under consultation headings while in the other method free text entries are explicitly linked to coded data items. Patient history or examination findings related entries and comments detailing the overall consultation outcomes were the most prominent objectives observed for narrative data entry. There were five occasions where the main problem under discussion was described using free text, and in two occasions doctors did not select any representative Read code; leaving the narrative data entry as the only indication for the established problem. When entered linked with a coded data item, free text justified and elaborated the associated Read code. Prescription related fre text entries were mainly inserted as patient advice notes pertaining to the use of medication.

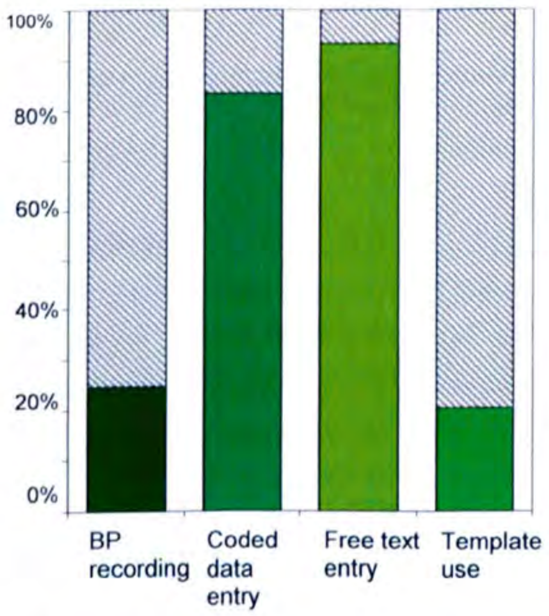


Figure 6.49: Proportions of consultations with different types of data recording tasks

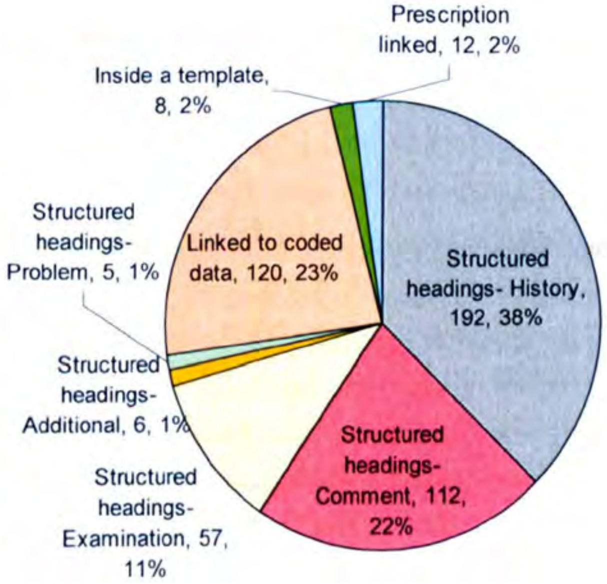


Figure 6.50: Different types of free text data entered

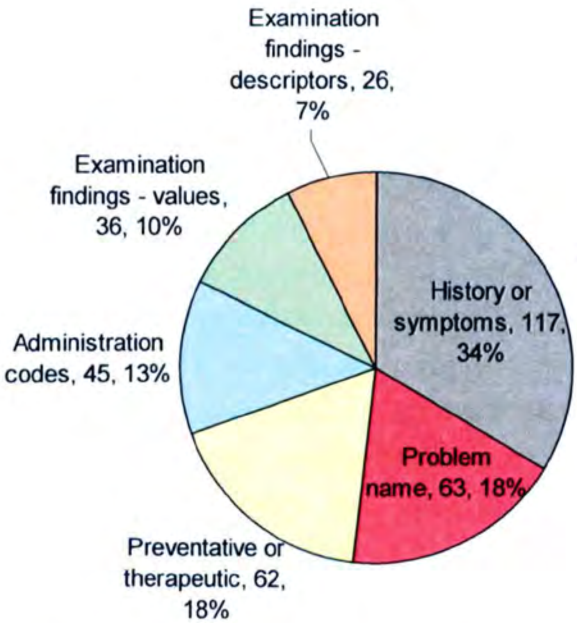


Figure 6.51: Different types of coded data entered

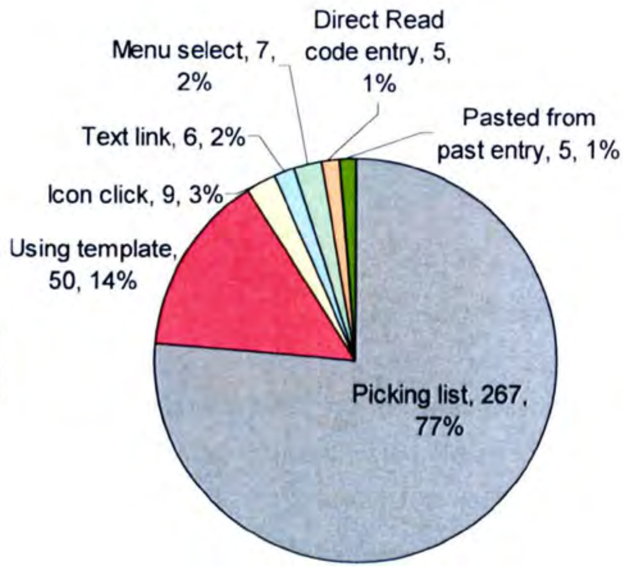


Figure 6.52: Different methods used for entering coded data

Doctors frequently captured the important terms representing the decisions and outcomes of the ongoing consultation into coded data items. In consultations where coded entry occurred, doctors spent about 20 seconds for searching and selecting the appropriate Read codes. This represent about 4% (mean=3.7%, SD=2.9%) of an average length consultations, on four occasions this took more than 10% of the consultation duration. One third of the coded entries (34%. n=117/349) represent Read chapters related to patient history and symptoms, while a similar amount is split between diagnostic (18%) and preventative or therapeutic codes (18%). Examination related coded data entries (17%) either indicated the meaning of the accompanying value, (e.g. alcohol consumption in units, pulse rate), or described the findings, (e.g. blood pressure raised, moderate drinker).

Doctors entered coded data mostly by searching using a term or key word and selecting the most appropriate code from a list; this represents more than three quarter of the coded entries (77%). Template use often resulted in capturing multiple Read codes, related to a specific condition or describing patient's general health profile. There are about 13% of the coded entries which for the most part represent doctors attempting to enter a coded item more rapidly, as an alternative for using the picking list. They took the form of copying and pasting, direct entering of the actual Read code or using shortcuts available in the interface.

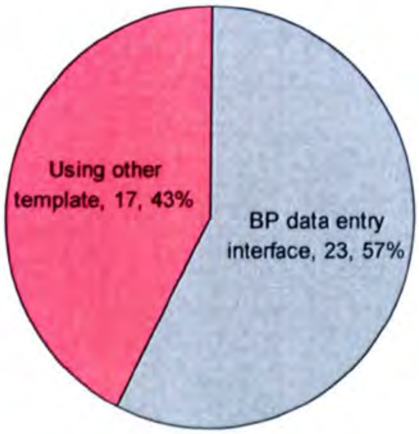


Figure 6.53: Different types of coded data entered

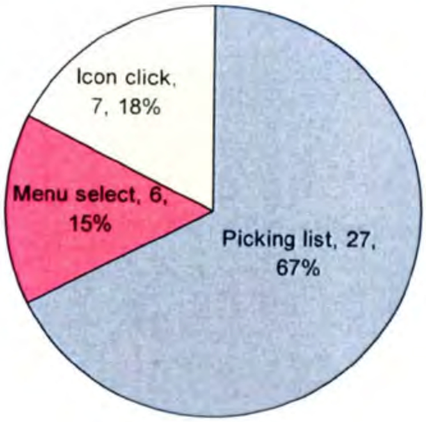


Figure 6.54: Different methods used for entering coded data

Recording of blood pressure could be seen as a separate structured data entry activity, often carried out in isolation from other data entry tasks. BP entry could be seen in 40 consultations (24.5%). Doctors entered the systolic and diastolic blood pressure readings immediately after a blood pressure examination activity in all but two of the instances. They used a recording interfaces created specifically for recording the two blood pressure parameters, spending about 13 seconds (SD=5s). It was 2.5% of the mean length of those consultations. While more than half (57%) of the BP data entry took place in data entry interfaces specifically designed to capture blood pressure examination outcomes, a considerable proportion took place in data entry templates designed to capture general health status data. The former approach involved additional navigation aimed at reaching the specific data input area allocated for systolic and diastolic blood pressure readings. As with usual coded data entry, doctors widely used (67%) the picking list approach to initiate the BP recording interface. The more long winded menu based and the faster graphical icon based approaches have also been used in similar proportions.

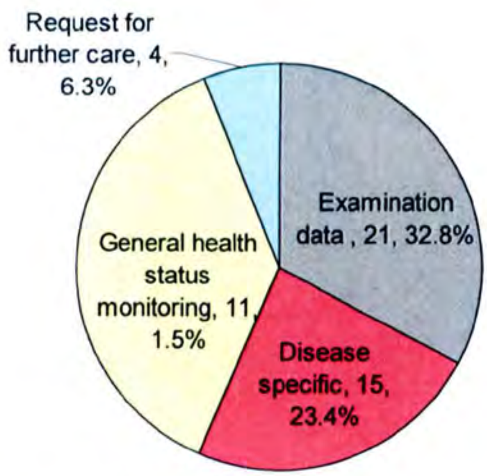


Figure 6.55: Different types of data entry forms used

In one fifth of the consultations (n=33/163, 20.2%), doctors interacted with data entry forms available in the EPR system. In average they spent 25 seconds (SD=40s), representing about 4.6% (SD=5.2%) of those consultations interacting with multiple data entry items available in those forms. The length of the time doctors spent interacting with the form was largely determined by the number of data input fields and the time taken to navigate between those. About one third of template use was associated with capturing outcomes of examinations procedures (e.g. height, weigh, BMI, peak flow readings, blood pressure, pulse rate). Nearly a quarter (23.4%) of the form based interactions was aimed at collecting disease specific data, cardiovascular risk related data capturing is the commonest (n=12). General health status screening data entry forms covered wide range of topics from family history to outcomes of test results.

6.7.3 Taking actions – prescribing and other consultation outcomes

There were 139(85.3%) consultations where doctor-computer interactions associated with direct patient outcomes are visible. Majority of those (124/139, 89.2%), representing more than three quarter (76%) of the consultations in the study sample are related to prescribing related tasks. Altogether, doctors allocated nearly 7% (mean=6.9%, SD=5.3%) of the consultation time for reviewing the medications patient is currently on and creating new prescriptions.

In nearly half of the consultations (47.2%) doctors reviewed the existing medications in a list view spending about 25 seconds (SD=29s). All of the observed EPR systems offer dedicated areas with clearly visible categories for existing repeat and acute prescriptions. Doctors often reviewed through those lists, and in some instances filtered them based on the categories or explored further into areas were lists of discontinued scripts are available. In about half of the consultations (n=88/163,54%) doctors spent approximately half a minute (mean=31s, SD=19s) creating new acute prescriptions. Creation of a new prescription involved searching and selecting the specific drug, choosing the drug preparation, entering the dosage, quantity and supplying any special instructions if needed. Creation of a new repeat prescriptions involved the same set of interactions, only difference being the selection of 'repeat' as the prescription type and then specifying the duration its valid for; time spent is similar to that of an acute prescription (mean=33s, SD=35s).

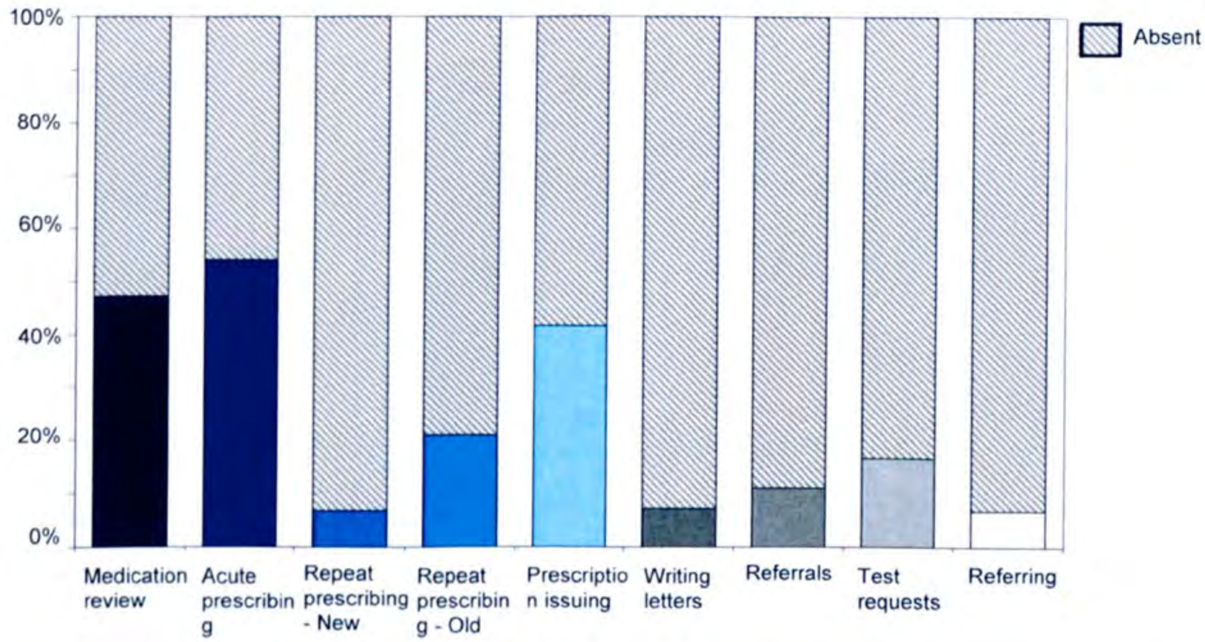


Figure 6.56: Proportions of the consultations with different types of tasks aimed at taking actions

Using an existing repeat-prescription takes less amount of time, as the interactions related to drug selection is not required. Repeat-prescribing was done in 34 consultations (20.9%). In comparison, it has taken about half of the time required for creating a new prescription (mean=17s, SD=10s) and represents 3% of the consultation length (SD=2.2%).

Issuing the created prescription is a straightforward task, however requiring a separate set of interactions in most EPR designs. The need to do a separate prescription issuing activity is partially influenced by the number of scripts newly created. Prescription issuing was observed in 68 consultations (41.7%), and has a mean duration of only ten seconds (SD=8s). In the remaining instances, issuing was performed as part of the new prescription creation process. The end result of this issuing process is the printed prescription, which is collected from the printer by the doctor and handed over to the patient.

In twelve instances (7.4%) referring the patient for further care has been the consultation outcome, resulting in doctor preparing a letter addressed to another health care professional. Doctors used a combination of approaches; dictating the letter or writing it using a word processer built-in or external to the EPR system. Even in situation where the letter was dictated, doctors referred to the medical record content to extract the necessary information. Computer use associated with letter compiling activities was 8.9% (SD=6.1%) of the consultation duration, this is about one and half minute of doctor-computer time (mean=1:23mins, SD=6:1mins). In one occasion where doctor decided to word process the letter during the core consultation, while interacting with the patient, it took more than six minutes (6:38mins). In 18 consultations (11%), doctors used EPR system features to make electronic referral requests or to generate referral forms containing patient details.

This has a mean duration of exactly one minute. On-line referrals involved more number of interactions compared to generating only the referral form, as the earlier approach required the selection of the referral site after comparing their waiting times.

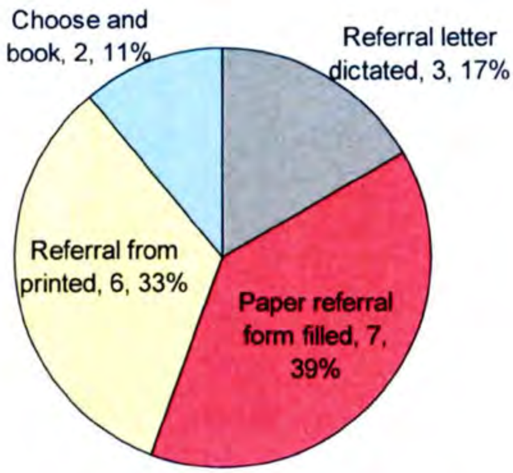


Figure 6.56: Different methods used for creating referrals for further care

Performing test requests is another activity that involved both computer use and paper based tasks. Doctors either used the EPR system to generate test request notes directly or used the presented information to complete the paper form. The mean length of doctor-computer interactions associated with test requests is 40 seconds (SD=48s). While taking actions linked with the consultation outcomes, in eleven of the consultations (6.8%) doctors could be seen looking up for information to make decisions or to educate the patients. The BNF was frequently used to clarify drug information (n=12/19), particularly their side-effect. In other occasions knowledge based articles provided by the EPR system (n=3/19) or publicly available on-line resources (n=4/19) were used. In two instances consulting doctor used general internet search engines to obtain images representing a medical condition, which they then shared with the patient and used for discussion. In general these information look-up type interactions represent more than half a minute (mean=34s,SD=34s) of the consultation length.

6.7.4 Overheads – delays, prompts and additional navigation

There were nearly 15% consultations (n=24/163), where the consultation workflow was hindered by unexpected EPR system errors or delays in responding to doctor initiated requests. Mean length of these system interruptions is 30 second (SD=39s). After interacting with the EPR interface, especially in situation where data was entered into a data entry from in a pop-up window or in occasions where a complex data entry form was requested, doctors faced delays in getting the desired response. Delays linked with prescription issuing and other document printing tasks were mostly associated with the time taken by the system to send data to the printer; the pop-up window which indicates the progress of the printing did not allow the doctor to interact with any other interface element.

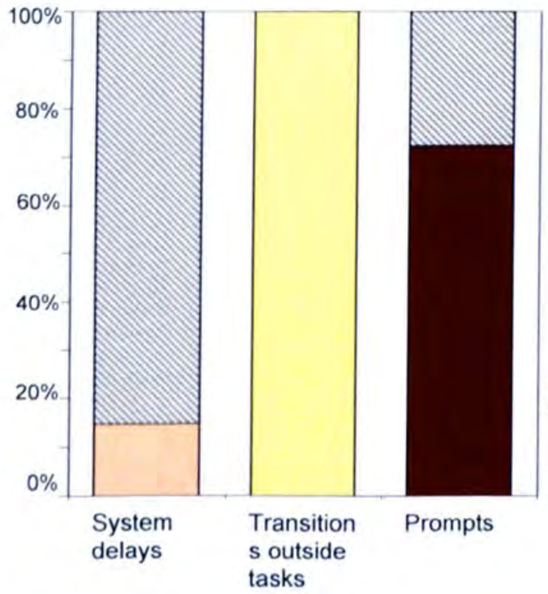


Figure 6.57: Proportions of the consultations with overhead type activities

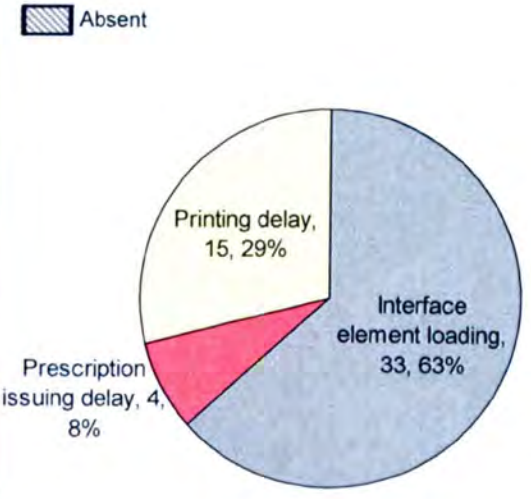


Figure 6.58: Types of system delays observed in the sample

When EPR systems were used for performing common consultation tasks, doctors spent nearly 5% (SD=3.12) of the consultation duration navigating between different functional features. Those interactions could not be linked to a specific purpose; they rather represent the additional time doctors spent to move away from the existing location of the EPR system before initiating another consultation task. With an average duration of 31 seconds (SD=21s), these extra transitioning interactions were noted in all consultation.

Nearly three quarter of the consultations (n=118/163, 72.4%) had instances where doctors were informed about incomplete information, incorrect data entries or reminded about facts related to patient history to support decision making. Doctors were routinely prompted by EPR systems at the beginning of the consultation, by presenting a summary of significant patient history and when prescribing, to acknowledge any concerns about drug interactions, allergies or medication review. These prompts mostly appeared as pop-up windows, requiring doctors to acknowledge. When prompts were associated with incorrect or incomplete information, which occurred more than 80 times in the sample, doctors had to deviate from the ongoing workflow and perform the necessary activities to resolve the data entry issues. Prompts associated with warning messages, resulted in doctors abandoning or re-starting failed interactions. Session management related prompts required doctors to supply information related to the ongoing surgery session, in most occasions (n=7/9) they accepted the default data shown in the form.

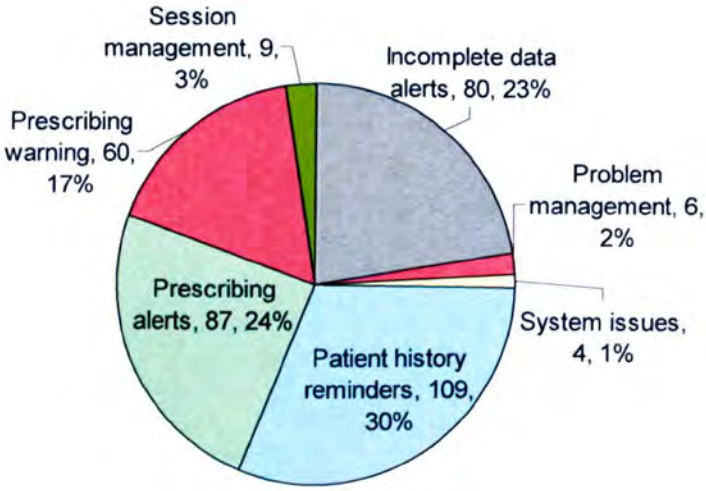


Figure 6.59: Different types of prompts and alerts observed

6.8 Distribution of common computer use tasks

There are distribution patterns unique to the type of common computer use task when their occurrences within the consultation length are considered. The majority of the information reviewing type tasks occurred in the initial marginal or first quarter of the core consultation (n=454/720, 63%). That observation is particularly valid for the past encounter reviewing and letter reading tasks. Doctors tend to review any available test results after patient is in the room, at the initiation of the core consultation and those types of tasks never occurred in the final marginal consultation. When information reviewing type tasks are performed in the second half of the consultation, they mostly were associated with verbal interactions aimed at patient education or planning of next steps.

Data recording tasks as a whole gradually increases towards the third quartile of the core consultation, however narrative data entry continuous to increase with the consultation's progression. Doctors waited until the problems associated with the consultation are framed before considering coded data entry; more than half of the codes were entered in the third and last quartile of the core consultation (n=197/349, 56.4%). More of the blood pressure recording occurred in the third quartile of the core consultation, while there were four instances where doctor entered the readings after patient has left the room by referring to the last readings recorded in their digital BP monitors.

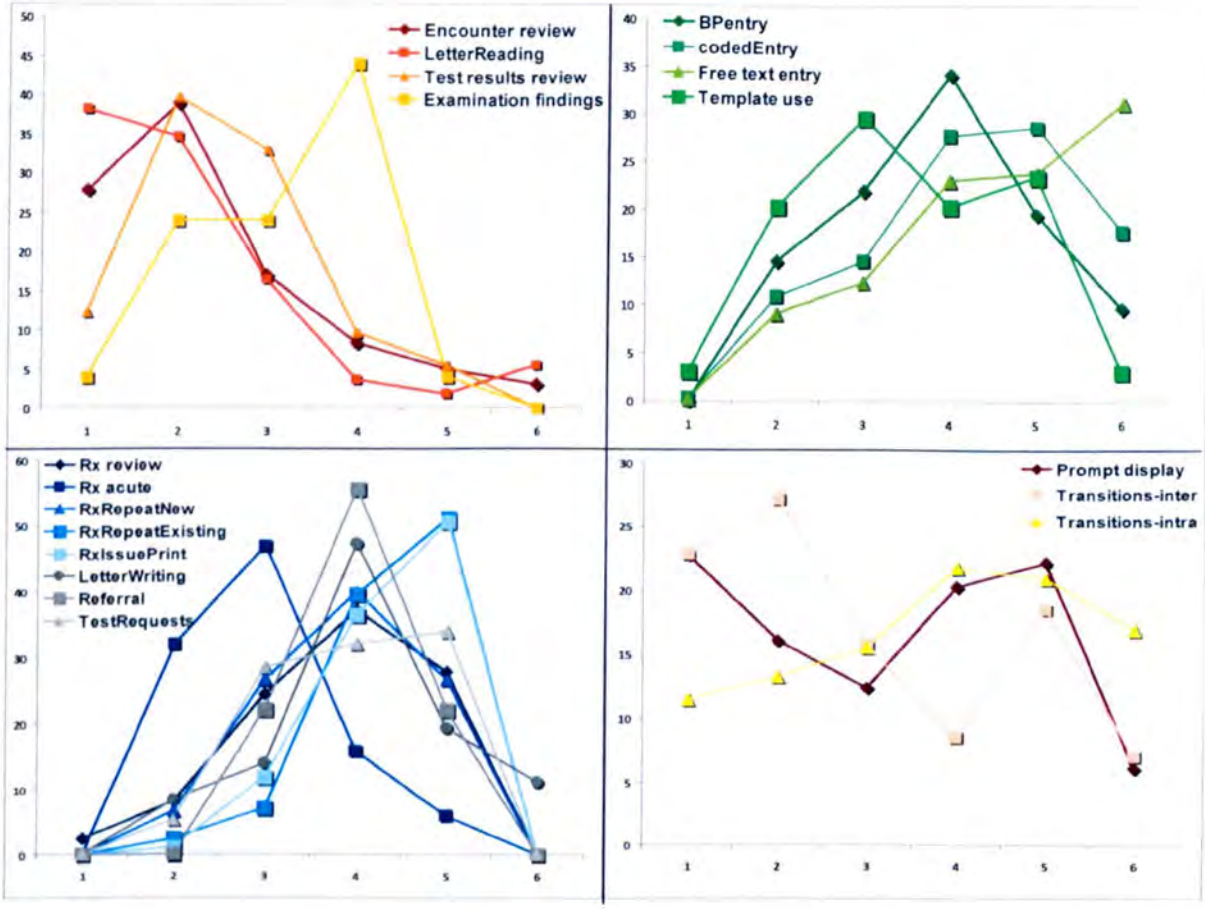


Figure 6.60: Distribution of common computer use tasks in the consultation time line (1=initial marginal consultation, 2 to 5 = quartiles of the core consultation, 6 = final marginal consultation)

Doctors performed taking actions type tasks mostly in the second half of the core consultation (n=321/529,60.7%). Nevertheless, nearly half of the acute prescriptions were created in the second quartile of the core consultation (47%). Creation of new repeat prescriptions occurred mostly in later stages, while re-authorisation of existing repeat prescriptions mostly happened at the very end of the core consultation.

Nearly half of the prompts doctors received from the EPR system were in the initial marginal consultation, where doctor started reviewing patient's medical record or at the end of the core consultation while data entry tasks are being completed.

6.9 Practical use of ALFand its adoption by other groups of users.

The ALFA toolkit allows greater precision of observation of the clinical consultation compared to other similar techniques. The current toolkit allows multiple video channels including screen capture, the consultation transcript, computer use, and speech to be precisely synchronised, timed and navigated through. The toolkit also allows other manual coding through the ODC tool to be added to the synchronised file. There is scope to add other inputs as required. During the observation stages of this study no significant technical issues were discovered. Due to the time limitations, recorded consultations have not been transcribed, thus the output from the voice activity recorder (VAR) was not considered in this study. However, during the coding stage a number of

verbal interactions related variables covering both the doctor's and the patient's speech has been introduced.
The author did not face any difficulty in setting up the technical components during recording sessions, and no concerns were raised by the patients or doctors who took part in the study. The subsequent stages of the ALFA; aggregation and analysis have also been carried out without any issues. As discussed in the technical method chapter, there a considerable efficiency gains associated with the production of the analysis output is evident.
The ALFA tool-kit has been mostly developed to meet aspirations to evaluate the impact of technology on the consultation. Its precise timestamps could be used to compare clinical computer systems or to contrast the time taken with paper systems with computerisation. The author hope that the produced UML sequence diagrams will be interpretable by software developers and enable better systems to be developed.
The ALFA toolkit can also be used to measure the performance of the clinician or the reaction of the patient. Colleagues who have seen this technique have suggested: remedial doctors assessed in simulated surgeries could be given multi-channel videos of their performance as a tool for reflection; and might be used as a formative assessment of communication skills.
The author has made the parts of the ALFA toolkit available to academic colleagues via an Open source licence. Currently there are two studies that use the ALFA as the data collection technique.
(1) The ALFA toolkit has been used in the TRANSFoRm (Translational Research and Patients safety In Europe) project to measure the effectiveness the decision support tools compared with usual practice. There, analysis outcomes form the ALFA are used to inform interface design for clinical systems; developing new principles that can be applied to the next generation of clinical computer systems.
(2) A SDO (Service Delivery Organisation) funded research at the University of Edinburgh looking into the effect of IT on interactions between healthcare workers and patients uses the recording and coding elements of ALFA. This research combines the ALFA with qualitative techniques to explore attitudes of stakeholders to the introduction of new information solutions and to inform future development.
The ALFA toolkit has been presented at nine national and four international conferences. The ALFA toolkit was launched at the European Federation for Medical Informatics (EFMI) conference, September 2008. The author has also conducted workshops at the MIE (Medical Informatics in Europe) 2009 and SAPC (Society of Academic Primary Care) 2009 conferences. The principal investigator, under whose supervision the author conducted this research, has been invited to deliver a plenary session at the North American Primary Care Research meeting in Montreal and at the Asia-Pacific Regional Informatics meeting in Singapore on the ALFA approach.

6.9 Summary

The ALFA toolkit allows detailed recording and comprehensive observation of the clinical consultation. This accepts the research hypotheses Hs1 and Hs2. Observation of EPR use in front line practice provides additional information not observed during simulations. Patients are willing to support research involving direct observation provided that they are given clear information about the objectives of the study and how data is used. Consenting process also has a significant influence on the patient participation, the two stage consenting and the involvement of the practice staff resulted in having a low refusal rate in this study.

The mean consultation length is between eleven and twelve minutes. There were no significant differences between the durations of the consultations linked with the EPR system used. As a result the research hypothesis Hs5 has been rejected. Despite the considerable heterogeneity of computer use observed between systems, clinicians appear to devote a consistent proportion for carrying out routine tasks using their EPR systems. However, there are aspects associated with the interaction quality that are influenced; for example if GPs found a particular data recording task difficult to perform, they might abandon it completely rather than prolonging the computer use duration.

The rest of the results discussed in this chapter positively acknowledge the remaining set of research hypotheses considered in this chapter. Doctor-computer interactions are different based on whether they take place before, during or after patient is in the room. Doctors' computer use is primarily split between tasks for reviewing information in the medical record, making new record entries and taking actions. Initial tasks are mostly aimed at reviewing patient's medical history. Doctors routinely go through lists of past encounter data before inviting the patient in. Free text entry taking about one minute, is the biggest proportion of data entry. Prescribing is the most common computer use task associated with consultation outcomes. Doctors' interactions towards the end of the consultation are mostly aimed at record maintenance or recording consultation outcomes.

There are contextual elements playing a significant role in defining the interaction structure of the consultation and recognising them is essential for construing the associations between the technology and the consultation process. This finding accepts the research hypothesis Hs3. There are a number of findings that contribute to elaborate the factors associated with this hypothesis further. Many consultations are not simple one to one events. In over a quarter of the consultations there is more than one person in the room, which appear to have an influence on the consultation workflow. Majority of them were situations where patients arriving with either their children or parents. Only a minority of doctors have inclusive or exclusive room layouts. The commonest room layout had the patient in the doctor controlled semi-inclusive position where they could not naturally observe the content of their EPR without changing the seating position or clinician turning the computer screen. The method clinicians used for calling their patients in appear to influence the start time of the greater consultation. Interruptions occurred mostly in the core consultation, however they appear to be longest when occurred after patient has left the room.

CHAPTER 7

Results II - Common consultation tasks: workflow and process models

7.1 Chapter introduction

This chapter offers a detailed view of doctor-patient-computer interactions by using a selected set of common consultation tasks. UML Sequence diagram process models associated with common computer use tasks are presented followed by discussions aimed at interpreting the key findings. Results are analysed referring to the EPR interfaces and also to specific observations from the multi-channel videos. Results presented in this chapter are primarily associated with the research hypothesis Hs7 and Hs8, where the influence of specific clinical system design features are considered to be related to consultation tasks and process modelling approaches are considered as capable of recognising such relationship. Furthermore, the quantitative findings presented in this chapter elaborated more specific factors associated with the Hs4 and Hs6, providing details about observable associations for task durations, underlying work flows and their occurrences within the consultation.

The interpretation of the process models has been specifically aimed at ascertaining the system features that are capable of promoting patient engagement. Discussions here also reveal the design characteristics that offer patient history related information framed by a biomedical structure, how some monor changes in data presentation could promote patient-oriented interactions and interfaces that influence doctors to capture large amount of data with less utility. Each process model is first introduced by describing the sequence of interactions, which are structured with sub-headings indicating the core design characteristics associated. After introducing the process model associated with each EPR system, influence those computer use tasks appear have on the consultation workflow, social interactions and the outcomes of the consultation are discussed.

7.2 Main interface structures

During a consultation, the bulk of the interactions are performed with a default 'consultation mode' interface (figures 7.1). The core functional features and information significant for the consultation are prearranged into this interface. For this default consultation view, LV has a single window layout with functional areas spread across multiple pages. PCS and Vision systems use sub-windows to compartmentalise different functional and presentation areas. Vision's interface has a relatively complex layout with a large number of graphical icons for navigation arranged in rows, and a summary data area with useful abstracts of the medical record content presented under a number of headings and packed into a navigable tree structure. Vision users had to select the useful heading and expand the menu tree to retrieve a required piece of information.

Both Vision and Synergy utilise the 'tabbed interfacing' approach to present the functional areas organised in multiple pages, which are accessible using the respective tab header. Like Vision, the Synergy's interface also uses a large number of graphical icons to act as navigation links. While these rows of navigation icons take up less space in these two systems, the LV interface's group of text links occupies a considerable portion of the display area, regardless of the functional area the user is dealing with.

Although the coded data entry process is implemented to an equivalent degree in all the popular EPR systems, still differences exist in the data presentation and the item selection process (Tai,2007). Similarly, there are fundamental differences between the systems in terms of the mechanisms available to retrieve encounter, medication, test results, clinical notes, attachments, X-ray images and so on. Even within the same system, different methods exist to perform the same task; e.g. clicking on an icon, selecting using a menu or pressing a function key. The way the interfaces respond to user's actions also differ, some acknowledge the success of the interaction by color changes or confirmation messages, while some systems do not. There are also significant dissimilarities in the implementations of the reminder mechanisms, displaying of error messages, retrieving attachments, viewing decision support information, generation of summary data and stages for prescribing medications.

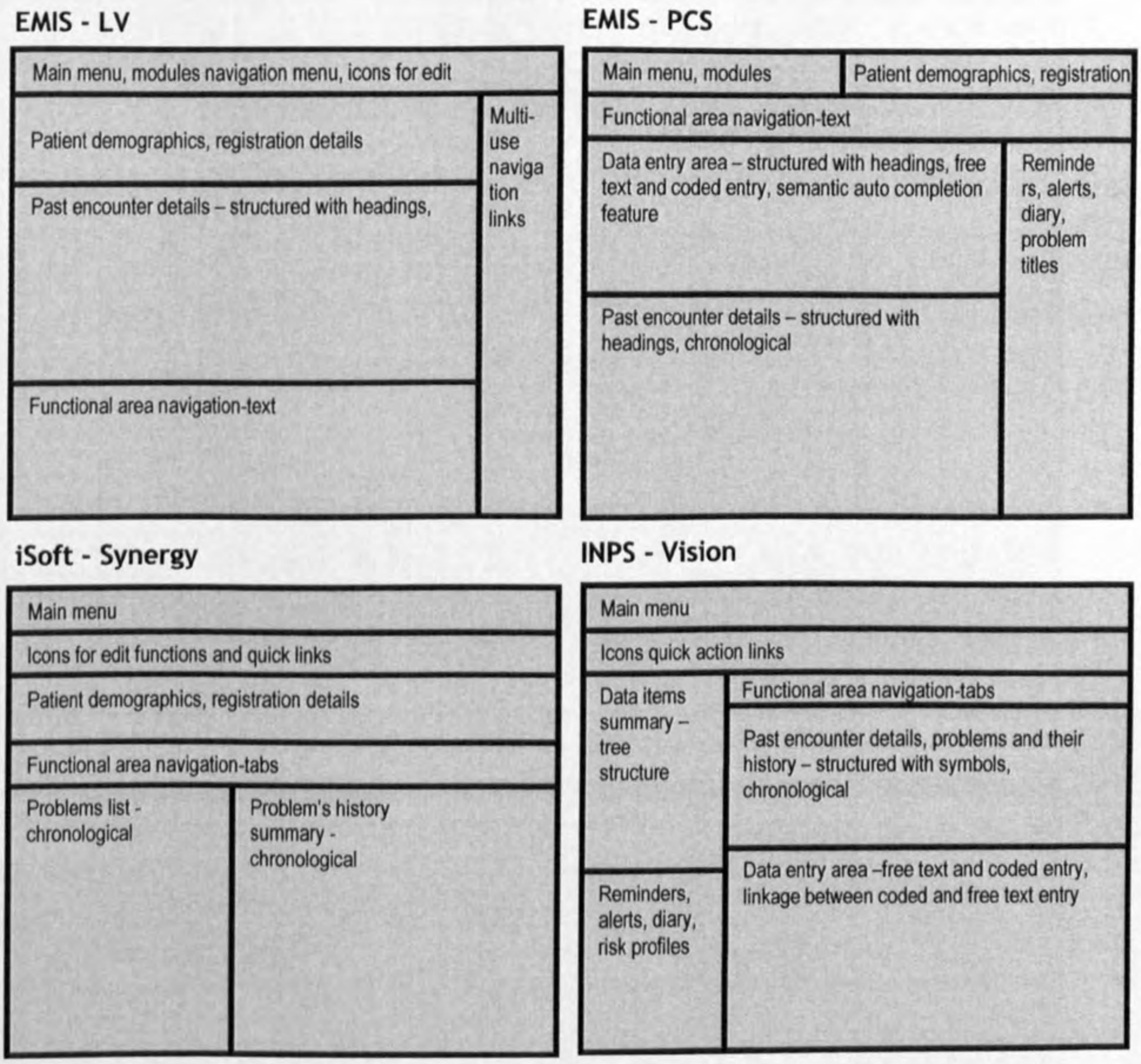


Figure 7.1: Schematic diagrams showing the functional areas of the default consultation interfaces

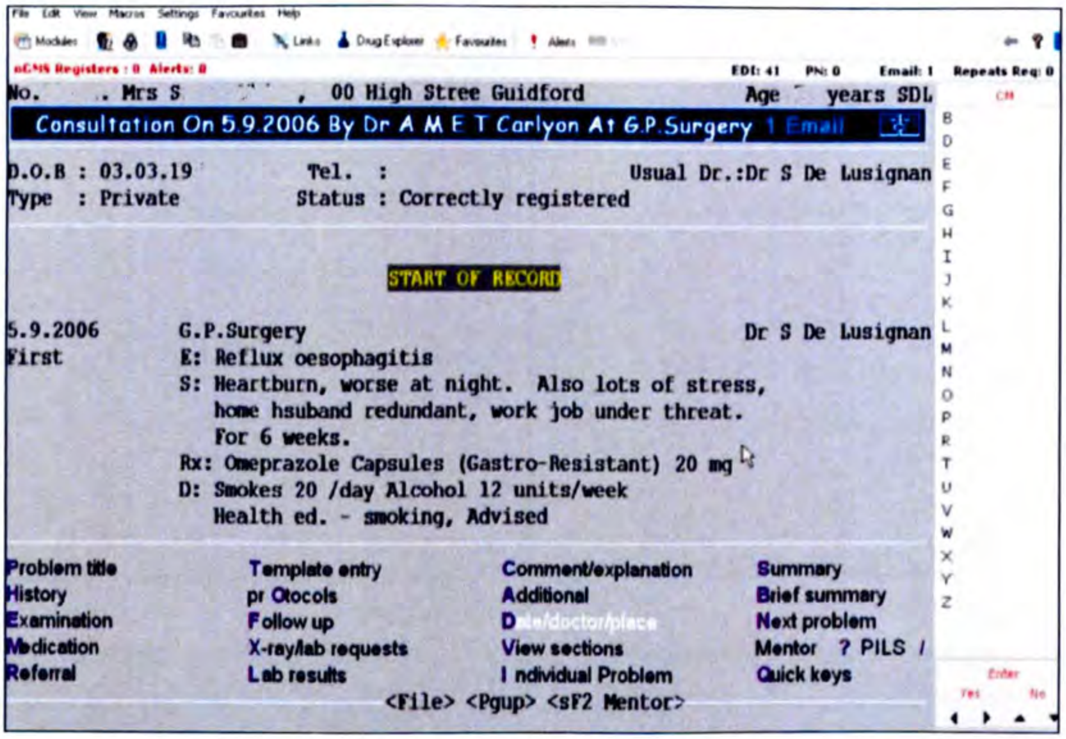


Figure 7.2: Default consultation view of EMIS LV system. (Main data entry tasks take place in the middle section, while a header area displays patient's profile. Main navigation tasks are done using the set of text links available in the bottom part of the screen.)

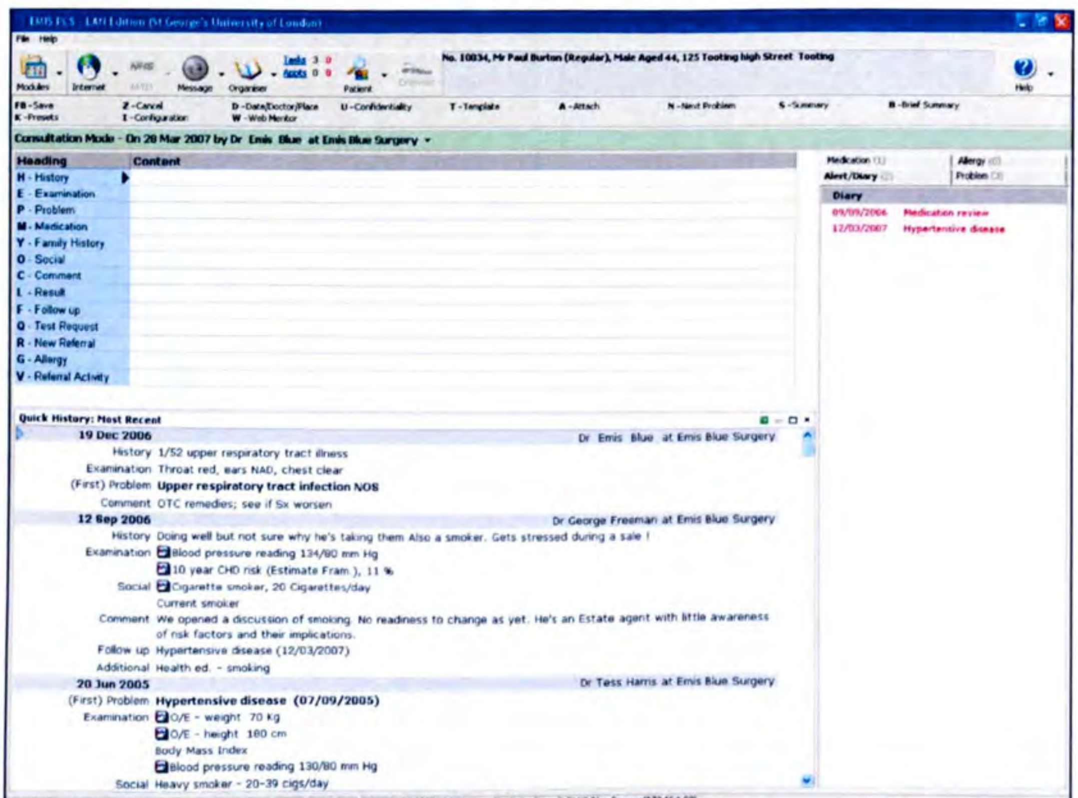


Figure 7.3: Default consultation view of EMIS PCS system. (Both coded and free text data can be entered into the input fields next to the set of consultation headings. Past encounter summaries are available throughout the consultation in the lower part of the screen, while the right hand side sub-window displays the important reminders and alerts.)

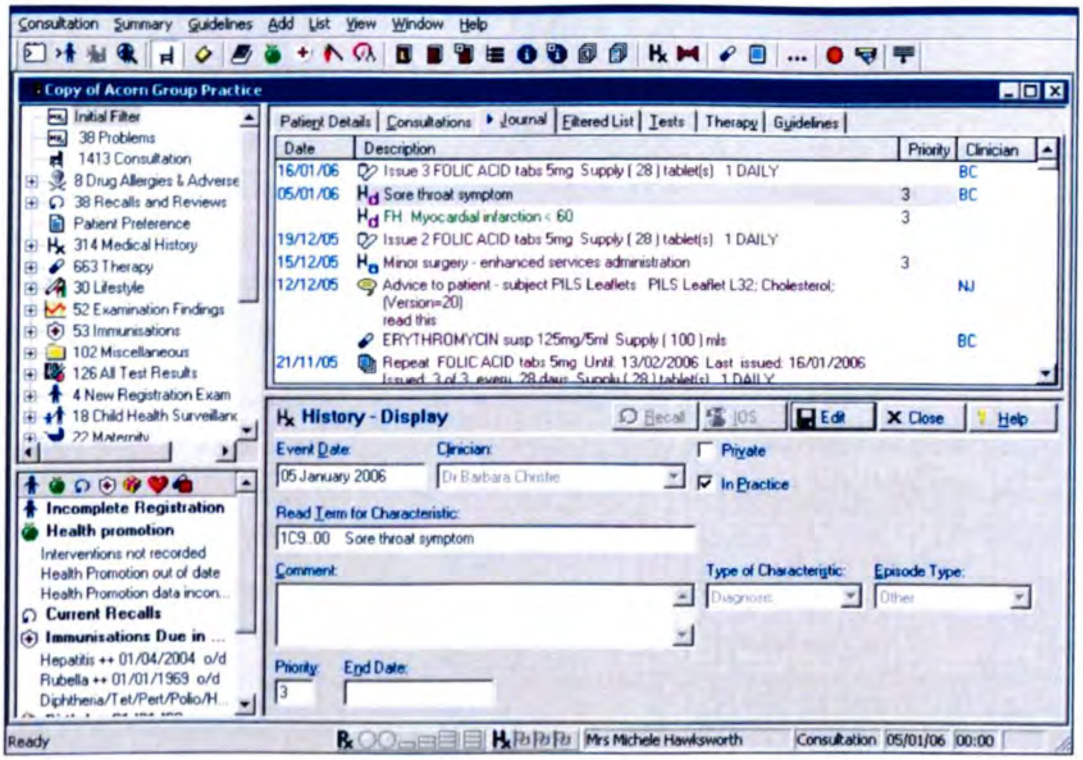


Figure 7.4: Default consultation view of INPS Vision system. (Main consultation area consists of four sub-windows. Right hand side panel has past patient history data grouped into a menu tree. Main consultation sub-window has tab-separated sections, each having lists of data with icons indicating the type of each data item. The data entry area in the bottom expands when data is being entered)

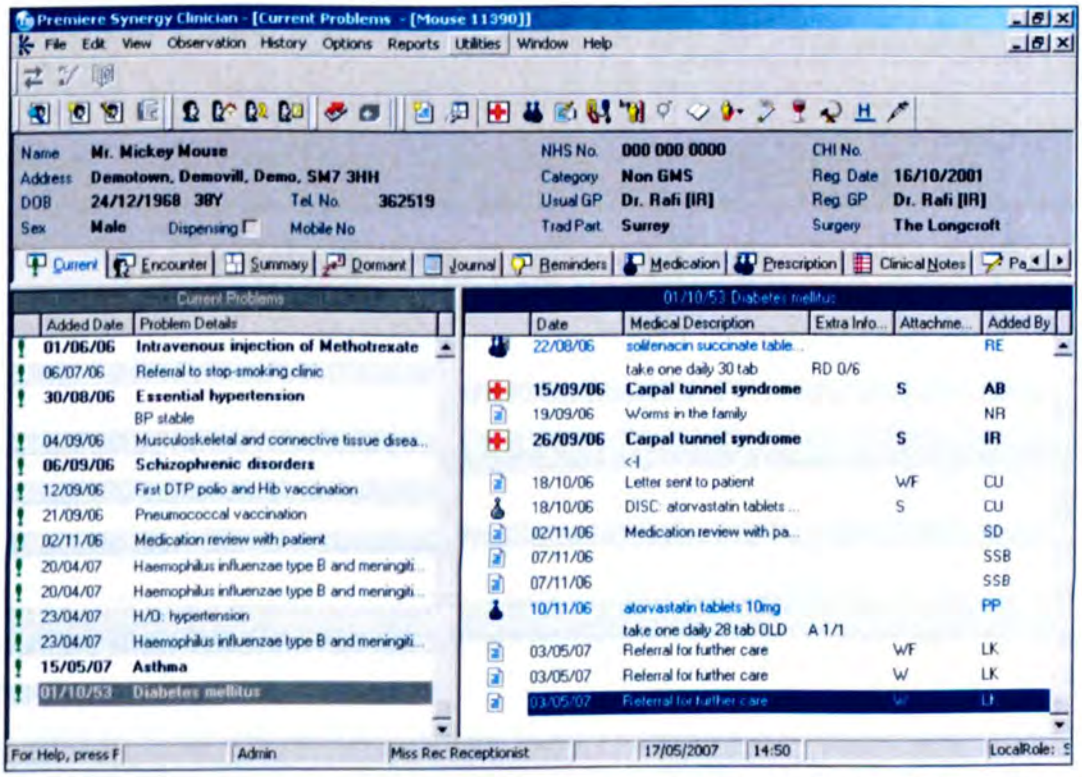


Figure 7.5: Default consultation view of iSoft Synergy system. (Main consultation area consists of tab-separated pages. The 'Current' tab is predominately used during the consultation. It has a list of problems in the left hand side sub-window, with encounters associated with a selected problem appearing in the right hand side sub-window.)

7.3 Encounter and test results reviewing

7.3.1 Reviewing the record – LV

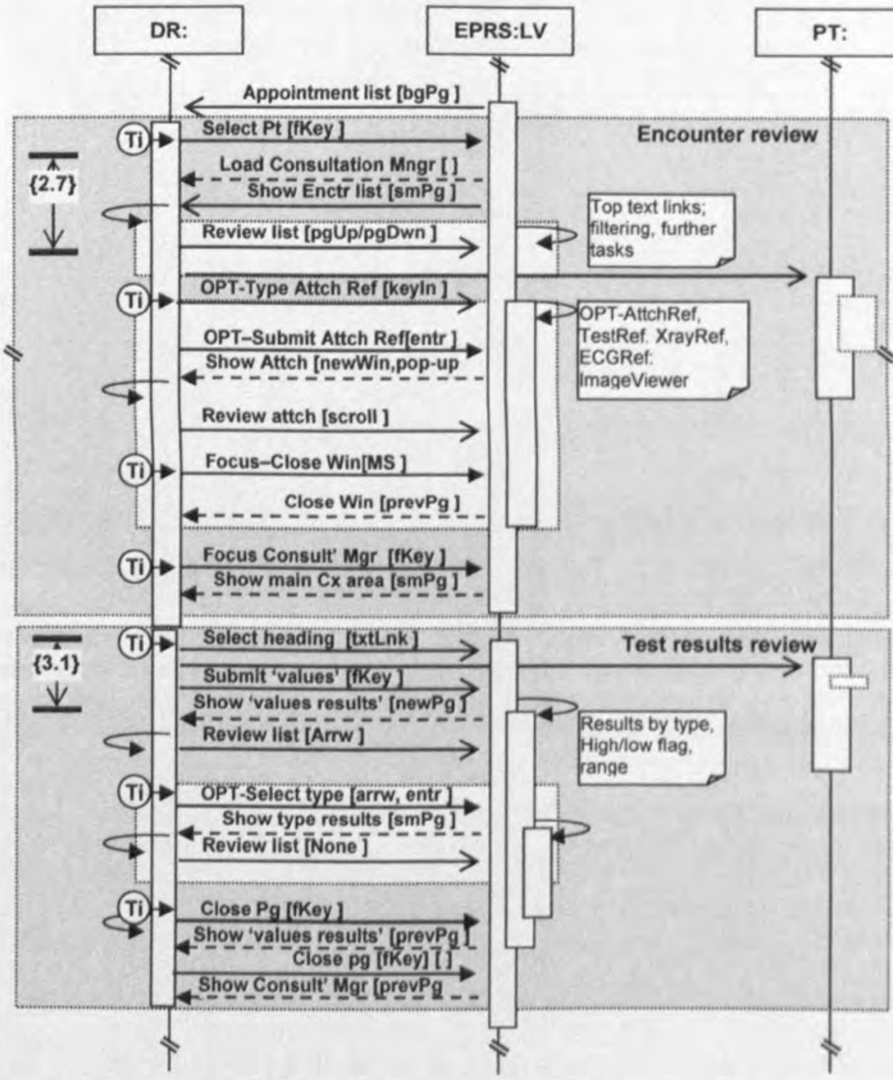


Figure 7.6: Process model of encounter and test results reviewing in LV

Default use of encounter history page at initiation

In all consultations with LV, doctors visited the past encounter section immediately after selecting the patient from the appointment list. They selected the *consultation manager* option to initiate a new consultation for patients. Its initial screen presents the data entries from last consultations for the selected patient, LV users interacted with this screen routinely before moving on to the main consultation data entry page. This pattern of use is due to the fact that when they are in the main consultation page none of the historical data are visible. LV users have to navigate away from the main consultation page to review specific patient history related items if needed.

Structured past encounter data with single letter labels

LV's past encounters section has chronologically organised medical record entries, grouped based on the date of entry and then by consultation headings. Each entry has the main problem title at the top, followed by structured set of individual record entries shown next to a single letter label; these letters indicate the consultation heading types. However, these labels are not directly linked to the actual heading names they represent (for example '*E*' for *problem title*, '*O*' for *symptoms and signs*, '*T*' for *examination findings*).

Navigation key based reviewing of encounter data entries

Both coded and free text entries are displayed in the encounter summary. Users frequently interacted with the navigation keys (Page-up and Page-down) to review the past encounter details. The number of consultations covered by a single screen depends on the amount information in each entry, in average there were two to six entries in each page view.

Viewing of attachments by submitting their reference numbers

Letters from external health care professionals or test results are attached to the medical record. They are indicated within the consultation summary by unique reference numbers displayed inside brackets. A text label before the document number indicates the type of the document or an indication about the outcome or both. For example as '*Serum TSH level, normal, no action (R104)*'. Doctors were also seemed to be aware of the type of the attached document based on first set of characters in the reference number (e.g. *R1* for electronic results, *RA2* for scanned letters). LV users have to type this reference number after pressing the asterisk key ('*') to open the specific attachment or view the detailed test results.

Reviewing of test results

Entering the reference number for an electronic test result opens the detailed test data sheet in a new page. Followed by the introductory information about the type of test, value for each parameter is displayed with the reference range and an indicator for out of range instances. LV users interacted using the navigation keys to review through the data screen.

Reviewing of scanned-in documents using the *Image viewer*

In situations where the submitted reference number represented a scanned-in paper document, a separate window appeared (*EMIS image viewer*). Doctors then viewed the document interacting with the newly displayed window, in most occasions they interacted using the scroll bars to navigate through the document. Doctors used the mouse pointer to close this external window.

Function key based navigation to the main screen

If the past encounter reviewing tasks have resulted in moving into separate areas of the patient's medical record, LV users repeatedly pressed the 'F1' function key to navigate back to the main consultation screen.

Combined display of examination and test results data

When reviewing patient history within or outside the *past encounter mode*, LV users often visited a single interface area to review both examination findings and test results. They used the character keys assigned to various text links, using at least two steps to reach the '*values and results*' section. This screen displays all recorded test results or examination outcomes with numeric data, such as blood pressure readings and Serum Creatinine levels, Results are grouped by their types.

Data columns specify the data type, outcome and unit associated with each text or examination. Another column indicates whether the outcome is abnormal, using a single character flag ('t') and a final column shows the normal range for the outcome value.

Obtaining a filtered list of examination or test outcomes

When users wanted to explore an exact test indicator further, they did so by selecting an individual line of data, which presented a new page with all historical readings for particular test or examination item. For example, selecting the latest Serum Creatinine reading, lists all past recorded values of the same, as date and value pairs. Similarly, doctors wanting to review the past blood pressure readings, selected the latest row of data with the description '*Blood pressure*' and obtained a new page with all recorded systolic and diastolic values. The top set of text links indicates various options to filter or group the available results. Users had to reverse the navigation steps to go back to the main consultation interface.

7.3.2 Reviewing the record – PCS

Use of main consultation area for past encounter data reviewing

PCS users mostly interacted with the main consultation page, without changing its default content for encounter reviewing tasks. Selecting a patient from the appointment list loads the main consultation window with the data entry area and the remaing sub-windows filled with patient history details.

Reminder messages based encounter reviewing

In 22 consultations, PCS systems were setup in a manner to display a medical history summary to appear as a pop-up window immediately after loading the main consultation interface. This reminder message contains a list of patient history data indicating the active and past problems, family history, reminders or diary events and examination and test results indicating health status. Test values and urgent reminders are shown in different colours, emphasising their importance.

Use of encounter summary data and reminders in main display

In situation where the consulting doctor decided to do the past encounter reviewing tasks using the main consultation interface, they mainly focused on the most recent encounter summaries visible in the bottom sub-window. This was then usually followed up by interactions with the right hand side sub-window which lists important reminder.

PCS users reviewing past consultations using the bottom sub-window navigated through the encounter entries using the mouse, interacting with the scroll-bar. This section of the interface lists the consultation entries ordered chronologically. Each element has the problem term associated with the encounter in bold text, followed by any free text or coded data shown underneath. The free text entries are structured; they are organised using the consultation headings, which were used originally at the time of data entry. Unlike in LV, headings are shown in full.

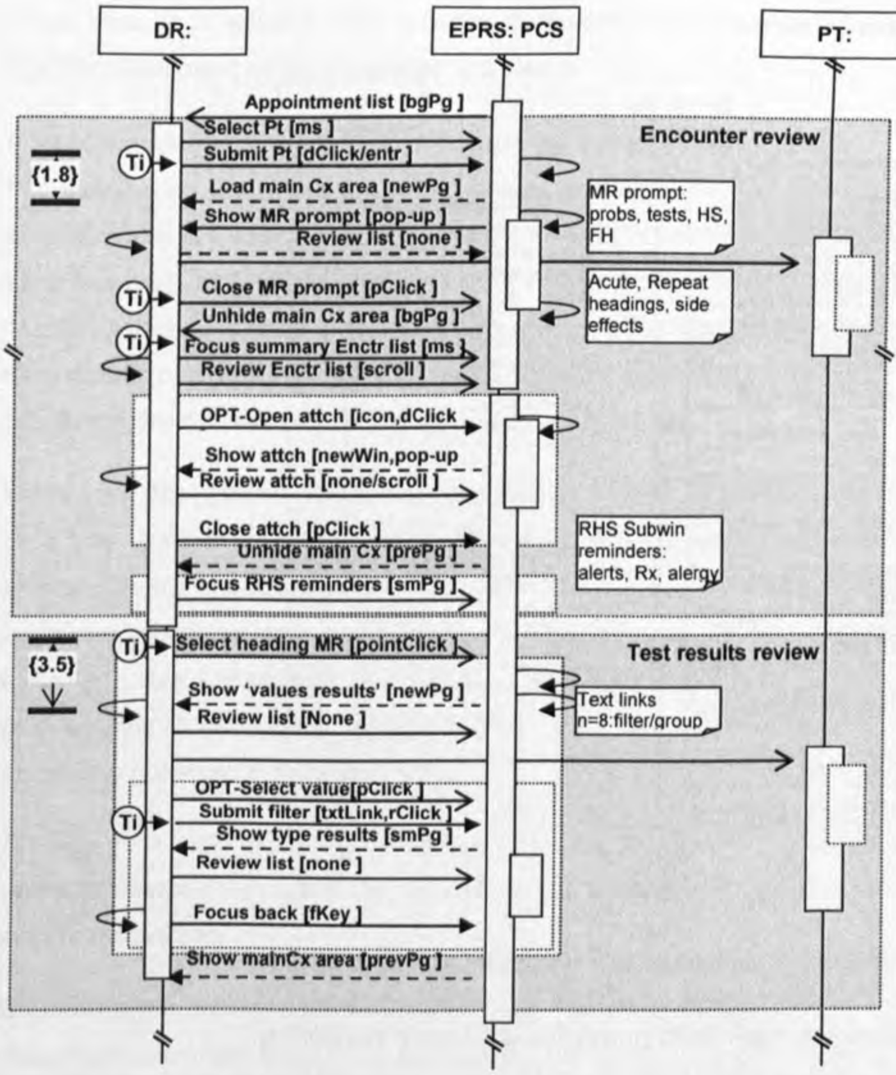


Figure 7.7: Process model of encounter and test results reviewing in PCS

Graphical short-cut symbol for attached documents

If documents received from other health care professionals are available, they are also visible in the summary view represented as a separate encounter entry. A paper clip symbol visually indicates the existence of an attachment, clicking on this opens the documents in a separate window.

Reviewing of reminders from tab separated list views

When interacting with the right hand side sub-window with reminders and important elements of patient's history, users mostly visited between the *alerts* and *problems* tabs. By default the alert tab is visible with the list of reminders underneath; the maximum number of items seen in this list was six. The problem tab is associated with a rather long list of terms representing recent problems that have been selected as the main objective for each encounter. This contains Read terms representing both clinical and administrative chapters (e.g. backache, repeat prescription). In number of occasions, the movement of the mouse pointer reflected the doctors reviewing process; mouse pointer moved from top to bottom, and as it reaches the end of the list the doctor started interacting with a separate part of the screen.

7.3.3 Reviewing the record – Vision

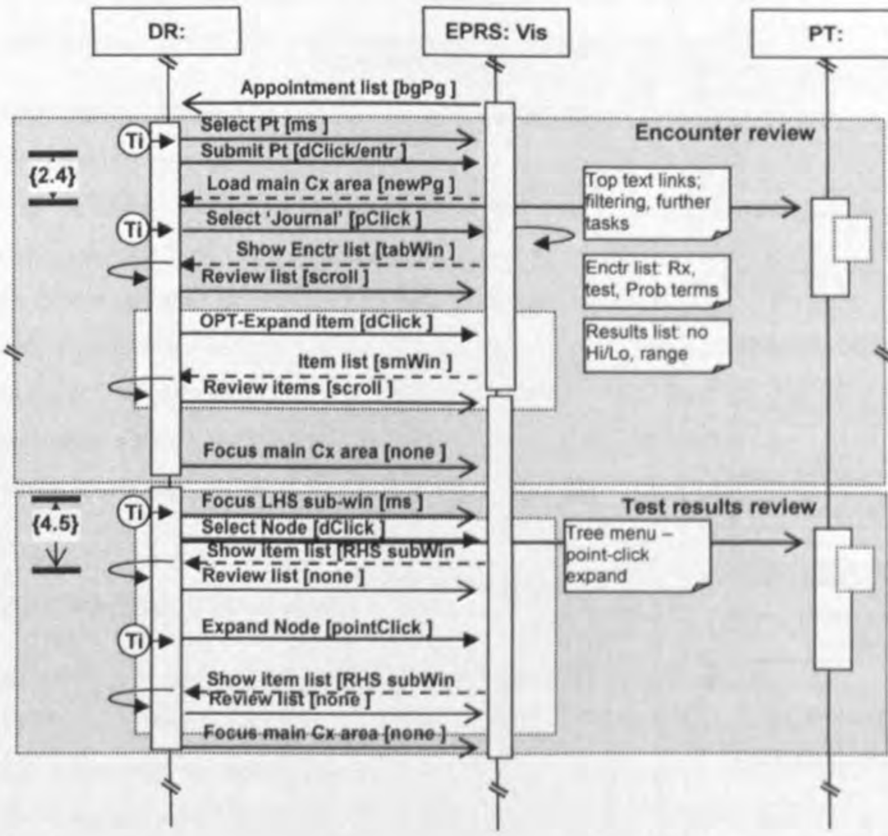


Figure 7.8: Process model of encounter and test results reviewing in Vision

Use of multiple sub-windows, tab-linked pages for encounter reviewing

When reviewing past encounters details Vision users visited a combination of tab-linked pages in the main sub-window and performed a routine set of interactions with the left-hand side sub-window. In most occasions they selected the main sub-window's *Journal* tab to go through a list of past encounter data.

Graphical symbol based indication of data entry type

A graphical icon at the start of each data line indicates the function of each entry. There were instances where doctors moved comparing lines with the same type of symbols, indicating the utility of this icon based visual structure. Otherwise there is no clear differentiation between the text and their numeric test values presented in journal entries.

Test results with no reference information

Test results list does not indicate the expected value range for each test item; it was up to the doctor to interpret any abnormal readings.

Scroll bar or arrow-key based navigation for encounter date

Doctors mainly navigated through the encounter list using the scroll bar. However, in instances where the main sub-window was having a reduced area, as a result of an expanded sub-window in the lower part of the interface, doctors preferred to use the navigation keys. They highlighted an encounter entry using the mouse pointer and moved the selection upward or downward using the arrow keys. In a reduced view, a slightest movement of the scroll bar changes could results in a significantly moving of the encounter lists view.

Interactions with the tree-menu structure for patient history details

In consultations where the top left-hand side sub-window was used for patient history reviewing purposes, doctors selected a range of nodes from the tree structure to obtain filtered results. There were two main nodes that were frequently visited by Vision users; examination findings and test results. Selecting a node in the hierarchical structure loads all the patient history related data for that specific category into the main sub-window. They appear in the page linked to the *filtered list* tab; taking the interaction focus away from the *journal* tab.

Reviewing past examination findings – single column based display of terms and values

Selecting the *examination findings* node, displays all recorded examination outcomes chronologically. The Read term for the examination name and any numeric values representing the outcomes are shown as a single data entry; there are no columns separating variable name, value, expected value and so forth. As in the encounter view, graphical icons visually indicate the types of examinations associated with each entry. Blood pressure reading and BMI measurements were commonly observed in the results set.

A single page view of the examination findings list could cover up to ten data items. Vision users rarely attempted to navigate through the list; the amount of data presented in a single view has a sufficient coverage.

Expanding the tree-menu for filtering patient history details

There were instances where doctors interacted with the navigation tree structure to obtain historical records of a single type of examination. It is possible to expand a node in the tree-menu and view the child element that sits underneath. For example selecting the *plus* sign in front of the *examination findings* node reveals the different types of examination such as temperature, blood pressure and weight measurement. A numeric value next to each child element indicated the number of records available. In situations where doctors wanted to review only the past blood pressure readings, they clicked on the child node of the desired type; for example selecting *blood pressure* child node within the *examination findings* node to view the past blood pressure records.

Selection scroll bar based navigation for test results data

When reviewing test results data, Vision users often navigated through the list view using scroll bars, even in situation where the main window is having a reduced area. Unlike the examination findings, results of a single test often are represented by a larger number of data rows; for example a single blood test result may involve readings for different indicators.

Recurrent use of same graphical symbol for all test result entries

Though grouped under a single date, each of these data rows representing different aspects measured by a single test has a graphical icon. Therefore the same icon repeated for each test parameter, providing very little visual cues to differentiate them. Outcome measurements are shown without a reference range, and with no indication about abnormal readings.

7.3.4 Reviewing the record - Synergy

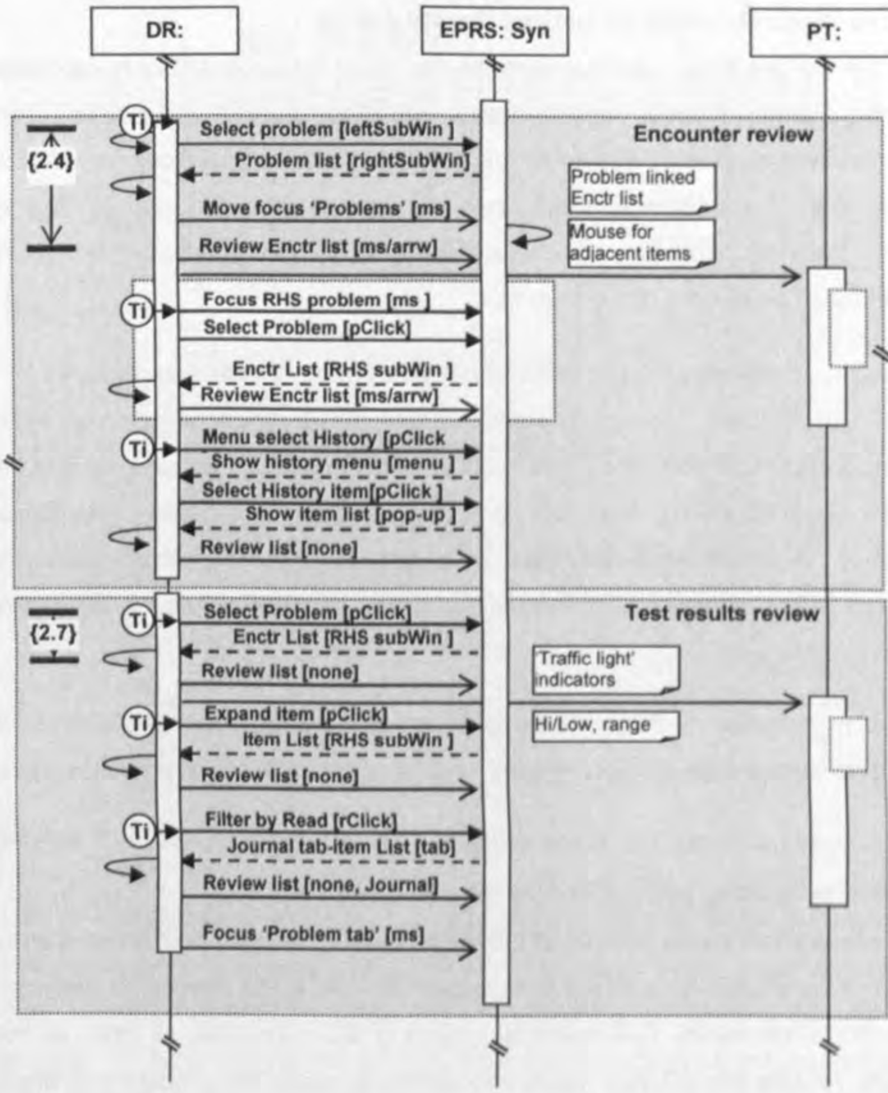


Figure 7.9: Process model of encounter and test results reviewing in Synegy

Problem oriented encounter reviewing

Synergy users adopted a problem based approach when reviewing record of past encounters. Problem linkage is central to the interface and functional features of Synergy; when entering coded data, free text entering and prescribing. The patient's encounter history is also organised under problem groups.

All three doctors who consulted using the Synergy system used the page linked to the *'current problems'* tab to go over the past consultation outcomes. After having an overview of the main consultation interface, they started selecting the problem terms listed in the right-hand side *'current problems* 'sub-window. Using the mouse pointer, Synergy users selected the diagnostic terms. They are easily recognisable from the bold text. Though the problem list is chronologically ordered, terms representing problems are not always adjacent; it is possible to have administrative codes or terms from other Read chapters in-between. In such situations, doctors moved between problem headings using the mouse, when they are adjoining they mostly used the navigation keys.

Individual displaying of multiple data entries from a single encounter – recurring date values

Selecting a problem title re-loads the right-hand side sub-window to display all associated encounter entries. This detailed encounter list represents each data entry associated with the specific problem, from all consultations. Both coded and free text entries are displayed in the *medical description* column. Free text element could be partly hidden due to lack of display area. A date value is shown for each data item; in situations where multiple data entries have taken place in a single consultation, same date value appears repeatedly. Medications prescribed, test results and examination findings are displayed in this sub-window. Each entry type is visually indicated by a graphical symbol at the beginning of the line.

Expandable test results, with graphical indicators for abnormal readings within

Synergy users expanded the test results when abnormal readings are indicated by the 'traffic light' indicators, to study the detailed findings and to locate the abnormal value. Synergy interface presents the test results in the right hand side sub-window's encounter list as an expandable data line. Only the name of the test result and date are displayed; detailed results with values for different test items are collapsed in the initial view. A plus sign at the beginning of the line indicates that this particular entry can be expanded into a detailed entry.

Synergy users particularly responded to situations when a red solid circle is displayed next to the test result name. This indicates the existence of one or more abnormal reading within the detailed test results. When expanded, each test item, value and expected range are displayed with colour of the text indicating any abnormal readings. The same red coloured symbol could be seen next to the exact test item lines with the out of range results.

Read code based filtering for test results

When Synergy users wanted to explore the changes of specific test item (e.g. Cholesterol levels), they applied a Read code based filter. They achieved this by right-clicking on the specific test item in the right-hand side sub-window, and then selecting *'filter by selected Read code'* option. This interaction results in moving the users' attention to the *'journal'* tab which displays all historical measurements of the chosen test item, from all available past test results.

Menu based selection for past examination findings, customisable overview outputs

To examine past examination findings of a specific type, Synergy users adopted a menu based approach. They interacted with the *'History'* menu, which provides options to obtain a graph or list view of different types of examination findings; blood pressure, BMI, smoking and so forth. Doctors that took part in the study used this facility to obtain graphical representation and lists of past blood pressure readings. The set of past readings appear in a separate pop-up window, its content can be customised to analyse the changes of the values in different graphical formats.

7.3.5 Number of encounter reviewing episodes

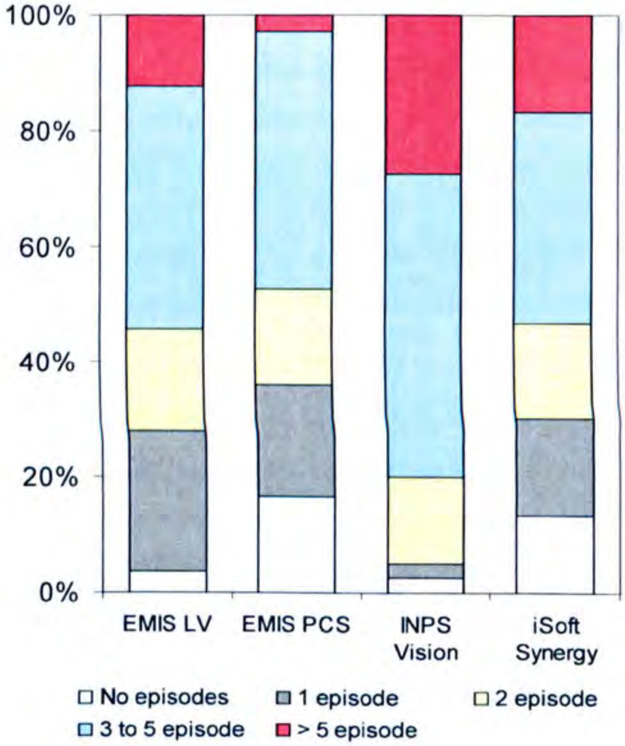


Figure 7.10: Proportions of the consultations, compared to number of encounter reviewing episodes, by EPR system

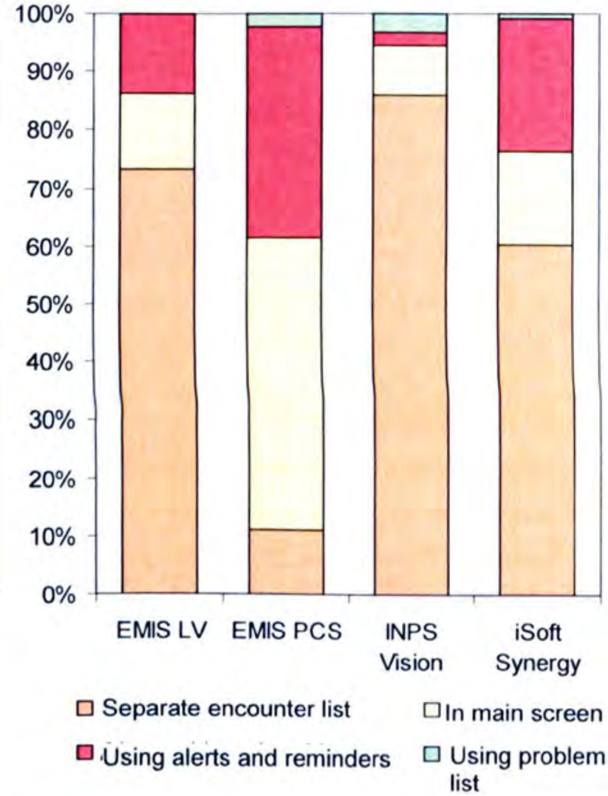


Figure 7.11: Proportions of the consultations, compared to methods used for encounter reviewing, by EPR system

The ease in which reviewing interactions can be performed, and the level of details provided in the encounter summary seem to have a relationship with the number of encounter reviewing episodes. The differences between the numbers of interactions aimed at encounter reviewing are significant between the four EPR systems; $p<0.001$. LV and Synergy systems are associated with similar mean number of episodes; about three sets of interactions per consultation (LV; mean=3.1, SD=2.0, Synergy; mean=2.9, SD=2.1). PCS users perform the encounter reviewing as a separate task least number of times (mean=2.5, SD=1.9) while Vision users perform such interactions most frequently (mean=4.7, SD=2.7)

In most consultations, doctors reviewed the past encounters three to five times. It ranges from 36.7% to 52.5% of the consultations conducted with all system.

There were considerable number of consultations with both PCS and Vision, where doctors did not navigate to or interact with specific interface features to study the encounter summary. In PCS and Vision interfaces, data entry interactions can be done without influencing the amount of patient history summarised in the main consultation view. On the contrary, In LV no such information is visible in the main consultation interface and in Vision the patient history area is reduced when the data entry section of activated.

The default consultation view in PCS, where a summary of encounters are permanently displayed, and readily accessible in a sub-window enabled the doctors to have fewer number of reviewing episodes; information is there to glance at as and when needed. Only 2.8% of the consultations with PCS have instances where doctor interacted with the encounter data more than in five occasions, minimum reported from the remaing systems is with LV (12.3%).

Vision users found it difficult to have an overview only based on the middle sub-window. The number of consultations where doctor could have an overview understanding of the patient's history with a single episode of reviewing is lowest in Vision consultations. Only 2.5% of Vision consultations had a single episode, while all other systems had at least 16.7% of the consultations with a single reviewing episode (maximum=24.6%, in LV). Proportionately, the number of consultations where the encounter reviewing occurred only twice is similar between the systems; they range from 15% to 17.5% only.

	Consult -ations N	Number of past encounter reviewing episode during a consultation									
		None		1 episode		2 episode		3 to 5 episode		> 5 episode	
		N	N%	N	N%	N	N%	N	N%	N	N%
LV	57	2	3.5	14	24.6	10	17.5	24	42.1	7	12.3
PCS	36	6	16.7	7	19.4	6	16.7	16	44.4	1	2.8
Vision	40	1	2.5	1	2.5	6	15.0	21	52.5	11	27.5
Synergy	30	4	13.3	5	16.7	5	16.7	11	36.7	5	16.7

Table 7.12: Number of encounter reviewing episodes by EPR system

7.3.6 Sections of the interface used for patient history reviewing

The area of the EPR system's interface doctors use to review the patient history related details depends on the amount of useful information they can retrieve with minimum effort. All four systems have sections of their interfaces where records of past encounters, list of active problems and reminders about important observations are communicated to the users, albeit in various details. In situations where important background information is available in the main interface, without needing to navigate to different sections doctors referred to them willingly. The PCS interface's encounter summary sub-window and right-hand side sub-window with important reminders were frequently used to recognise the important patient details, instead of going to its medical record view. PCS users performed the largest proportion of their reviewing tasks without leaving the main interface (50.4%, n=69/137). Vision users interacted with different sections of the main interface, changing its structure to retrieve encounter details, they did not do so only during 8.4% (n=18/214) of their encounter reviewing instances. In the Vision interface, the amount of information doctors can retrieve by only looking at the default screen without making any alterations to the format of the right hand side sub-window is very little.

Doctors referred to the list of problems associated with the patient only on a very few occasions, most of the time they needed to explore the patient history in greater details interacting with other parts of the record; only eleven consultations in the entire study sample (n=11/665). Lists of problem terms are available in all systems.

Difficulty in retrieving a useful overview about a patient's medical history while in the main consultation interface resulted in doctors visiting the dedicated pages with encounter summary. This behaviour is visible in both LV (73%, n=147/201) and Vision systems (86.0%, n=184/214). In both those systems, it is difficult to perform encounter reviewing tasks without leaving the main consultation interface. In Synergy interface, the main consultation area in-fact displayed the *journal* tab in most occasions. Therefore, consultations with Synergy also had a considerable proportion of the consultations where doctors interacted with encounter lists (n=68/113, 60.2%).

When a doctor notices a reminder message about significant information linked to the patients' history, it is often used as an aide memoire. PCS reminders, which appeared at the beginning of the consultation, contained a comprehensive summary of the patient medical record. PCS users had more than three quarters of the patient history reviewing interactions based on reminder messages (n=50/137, 36.5%). Synergy and LV users also utilised the system generated reminders to study the patient history (13.9% and 23.0% respectively). Vision users were rarely informed by reminders, for encounter reviewing (n=5/214, 2.3%).

7.3.7 Time spent on initiating and reviewing past encounter information

PCS users spent the smallest proportion of the computer use time reviewing the past encounter lists (mean=11.2%, SD=.3%). They mostly interacted with the main consultation view, where no additional efforts to navigate into different interfaces are required. Doctors using the Vision EPR system, where encounter lists are in a middle sub-window with individual entries separated by graphical icons and test results shown with limited structure, spent more computer use time (mean=14.6%, SD=11.8%).

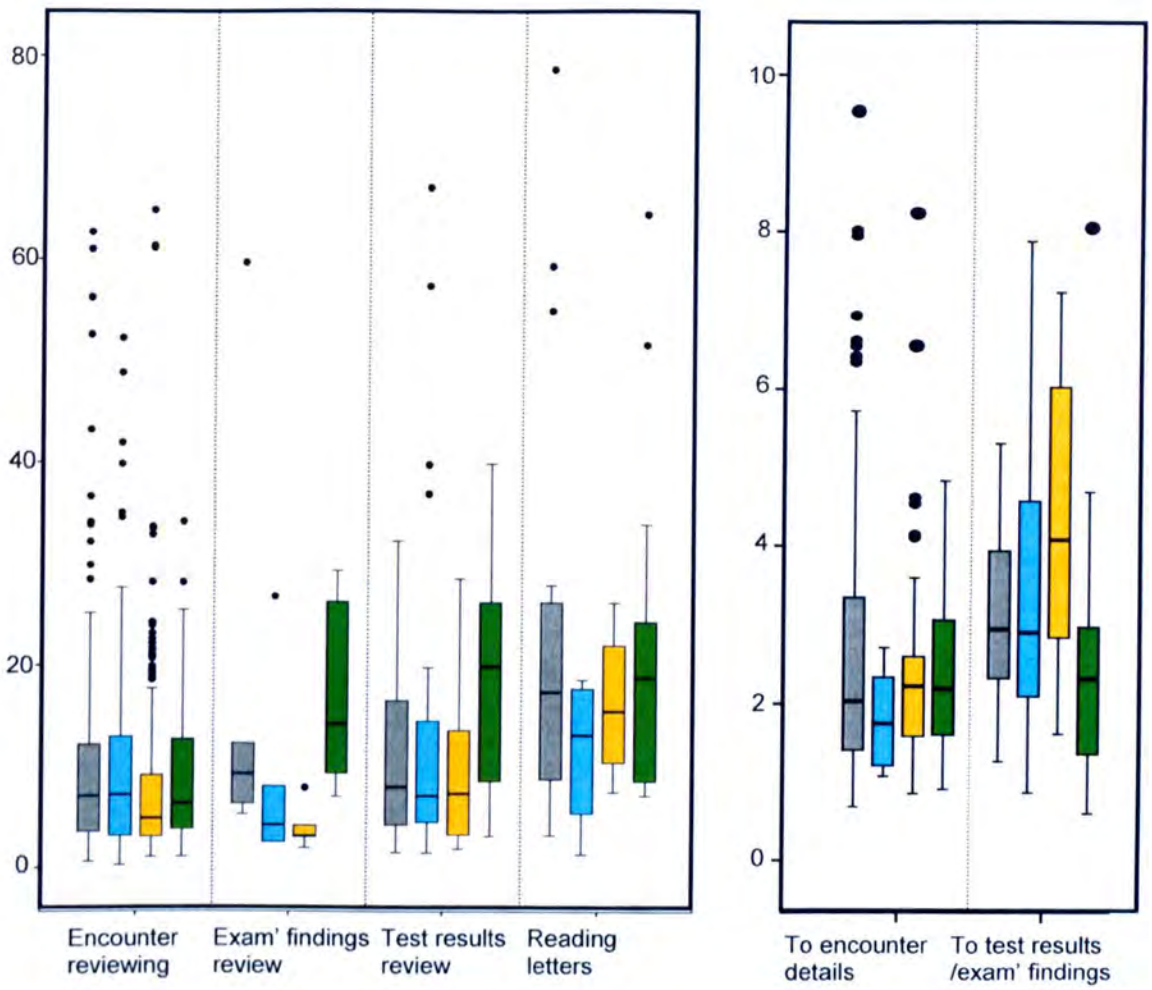


Figure 7.13: Box plots representing the time spent on medical history reviewing tasks and initiation of encounter or results reviewing tasks. (EPR systems are in the order of LV, PCS, Vision and Synergy)

The presentation of encounter data with limited structure, and often in a reduced area allowed Vision users to review only a small amount of information at each attempt. This computer use patten eventually has resulted in more number of consultation review interactions with shorter durations; though Vision users perform the encounter reviewing most frequently they spent the smallest amount of time per an episode of encounter reviewing (mean=8.3s, SD=9.6s). The pre-requisite for problem selection required Synergy users to spend about nine second for each interaction episode (Mean=8.6s, SD=6.7s). PCS users went through more number of past encounters within a single interaction compared to LV users, however the amount of time spent on each episode is similar between the two systems (PCS; mean=10.3S,SD=10.6s, LV man=10.6s, SD=13.1s).

The proportion of the consultation time doctors spent reviewing the past encounter details using encounter lists are similar regardless of the EPR system brand they used. This correspondence exist both when overview computer use and the detailed durations of single episodes are considered; no significant differences exist when the proportion of computer use time (p=0.593), the time taken for individual episode (p=0.372) or the time taken to navigate into a detailed encounter list are considered (p=0.178).

The significantly larger number of encounter reviewing episodes with shorter durations observed amongst Vision users are associated with the shorter navigation time required to move into the encounter list (mean=2.4s, SD=1.2s). Vision users easily moved into the detailed list visible in the middle sub-window, which is present even during data entry interactions. However, PCS interface is associated with the fastest navigation between the main consultation view ant the details encounter list (man=1.8, SD=0.6s). LV users, who had to interact with the text links spent the longest duration to reach the encounter list (mean=2.7s, SD=1.9s).

While the duration doctors spent reviewing past test or examination outcomes was largely influenced by their content and relevance to the consultation objectives, the proportion of time spent navigating were associated with interface features. Doctors using the Vision system made more number of interactions to explore past observations using the menu-tree; they have the longest task initiation duration (mean=4.5s, SD=2.4s). They particularly needed extra efforts to expand a specific item node to obtain a list view.

Synergy users managed to explore past test results more effectively using the expandable test results summary. The use of a solid red circle next to the result's name also enabled them to recognise the areas of the list that need attention. They managed to obtain a detailed view of the test results in 2.6 seconds (SD=1.7s).

7.3.8 Distribution of encounter reviewing interactions in the consultation timeline

LV users performed nearly half of the encounter reviewing interactions before inviting the patient in (46.6%). This could be associated with the fact that LV interface design requires doctors to navigate away from the main consultation area to review past encounter summaries; also opening of attached documents is more demanding.

Vision and Synergy users performed more detailed exploration of past encounter data (46.0% for Vision, 52.3% for Synergy) once the patient has arrived and objectives for the consultation are apparent. Difficulty in interacting with the tree-menu to explore more specific past results, or the compactness of the results presented in the default view might have influenced Vision users to delay such interactions, until their usefulness is established. Similar rational is visible in Synergy, where doctors have to expand individual item to review the detailed results.

Consultations with PCS, which allowed users to easily navigate between, encounter related summaries, had similar proportion of interactions distributed until the second half of the core consultation; as 28.1%, 29.2% and 23.6% sequentially for each consultation unit. It could be interpreted as an interaction pattern less influenced by the interface design; doctors continued to collect background information with the progress of the consultation towards the decision making stages.

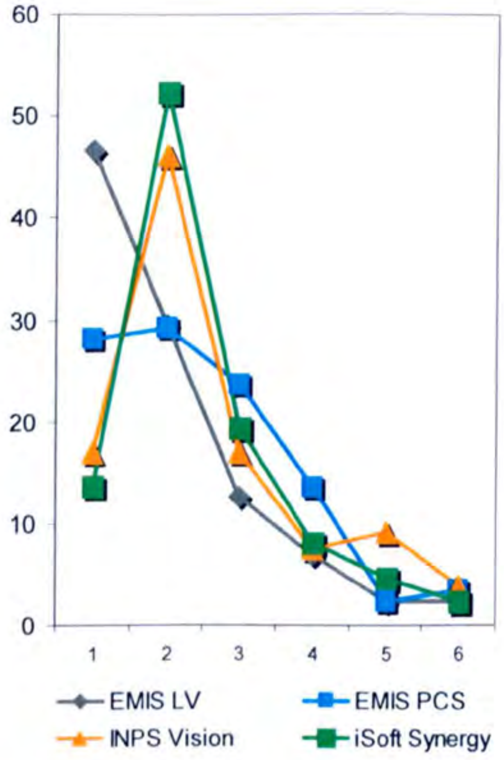


Figure 7.14: Distribution of encounter reviewing tasks across the consultation length (1-initial marginal, 2 to 4 = 1st to 4th quartiles of the core consultation. 6=final marginal consultation)

Distribution of past encounter reviewing tasks							
	Episodes N	**Initial-marginal (N%)**	**Core Q1 (N%)**	**Core Q2 (N%)**	**Core Q3 (N%)**	**Core Q4 (N%)**	**Final-marginal (N%)**
LV	176	46.6	29.5	12.5	6.8	2.3	2.3
PCS	89	28.1	29.2	23.6	13.5	2.2	3.4
Vision	189	16.9	46.0	16.9	7.4	9.0	3.7
Synergy	88	13.6	52.3	19.3	8.0	4.5	2.3

Table 7.2: Distribution of encounter reviewing tasks across the consultation length

7.3.9 Doctor-patient interactions parallel to the record reviewing tasks

Past medical history reviewing tasks within the study sample has nearly quarter of its overall duration (mean=22.9%, SD=19.3%) overlapping with doctor-patient verbal interactions. For doctor-patient eye contact, the overlapping proportion is 9.3% (SD=13.6%).

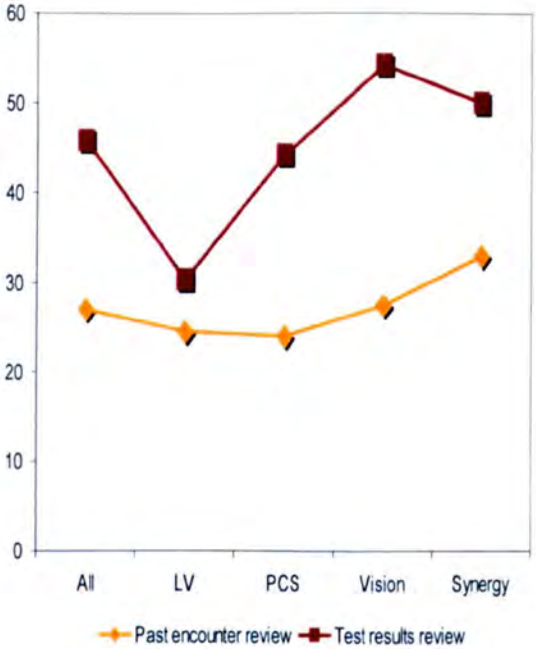


Figure 7.15: Proportion of encounter and results reviewing tasks with verbal interactions, by EPR system

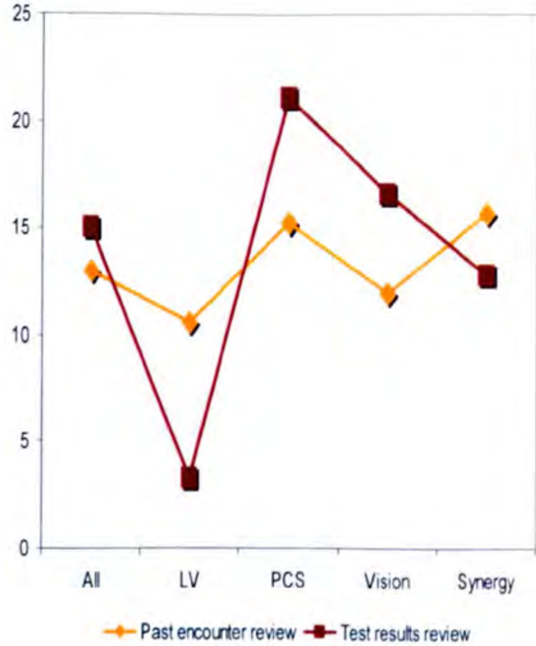


Figure 7.16: Proportion of encounter and results reviewing tasks with eye contacts, by EPR system

		Computer use task					
		Pas encounter reviewing			**Reviewing test results**		
		Cx N%	**Mean (t%)**	**SD (t%)**	**Cx N%**	**Mean (t%)**	**SD (t%)**
All	**Verbal**	79.3	26.9	18.1	80.6	45.8	25.2
	Eye	72.0	13.0	15.2	48.4	15.0	13.6
LV	**Verbal**	61.8	24.5	18.1	50.0	30.3	27.6
	Eye	49.1	10.6	11.7	20.0	3.3	0.4
PCS	**Verbal**	83.3	23.9	15.4	100.0	44.2	25.7
	Eye	73.3	15.2	14.8	57.1	21.1	22.4
Vision	**Verbal**	92.3	27.5	19.6	88.9	54.2	25.9
	Eye	100.0	11.9	14.5	55.6	16.6	8.6
Synergy	**Verbal**	92.3	32.8	17.8	100.0	50.0	20.2
	Eye	76.9	15.6	20.6	80.0	12.8	10.4

Table 7.3: Verbal interactions and eye-contact during encounter and test results reviewing tasks by EPR system

Regardless of the EPR system involved, doctors verbally interacted with their patient for about quarter of the encounter reviewing durations (mean=26.7%, SD=18.1%), while making eye contact for nearly half of the time they talk (mean=13.0%, SD=15.2%). Doctors using the LV system performed majority of their encounter reviewing tasks before inviting the patient in. They have the lowest proportions of doctor-patient interactions occurring in parallel to the computer use. PCS interface, which provides an encounter summary in its main consultation area and Synergy which uses a problem oriented patient history presentation strategy are associated with the largest proportions of doctor-patient verbal interactions with eye contact. Synergy users verbally interacted for about one third of the time (32.8%, SD=17.9%) they allocated for encounter reviewing, and nearly half of that involved eye contact (mean=15.7%, SD=20.6% of the total task length). In consultations with PCS, doctors verbally interacted for nearly quarter of the encounter reviewing duration (mean=23.9%, Sd=15.4%) and more than half of those periods involved eye contact (mean=15.2%, SD=14.8% of the total task length).

Encounter reviewing tasks during the core consultation were mostly prompted by the progress of the consultation, particularly the comments patients made when explaining the condition or past history. There were two occasions where doctor read-aloud the content of past encounter record, one of which was associated with reassuring the patient about the records of the previous consultation involving a different doctor. Doctors also made use of the past encounter entries to bring up new discussion topics, majority of them involved correspondence received from other health care professionals. In general, regardless of the relevant information provided by the past encounter data, doctors waited for a cue from their patients to initiate discussions around them.

Test results reviewing tasks involved the largest proportion of doctor-patient interactions amongst the record reviewing type tasks (mean=45.8%, SD=25.2%). Demands placed by the set of text links when exploring test results, and presentation of test results minimal amount of visual prompts, influenced LV users to focus more on the computer screen. Users of other three systems had the advantage of interacting with more visually organised test results data, with differently coloured text and graphical symbols indicating abnormal readings. PCS users were mostly interacting with test results data displayed using the entire screen space, which enabled them to move their attention between the computer screen and patient swiftly. PCS users are associated with the most amount of eye contact (mean=21.1%, SD=22.4%). Both Vision and Synergy users for the most part delayed interacting with patients, until the initiation tasks for obtaining the test results were completed; doctors of both systems had to focus more on the interface to select and expand the test results. Verbal interactions during test results reviewing involved explanations on different outcomes with reference made to their normal ranges and discussions about next steps.

7.4 Recording data into the medical record

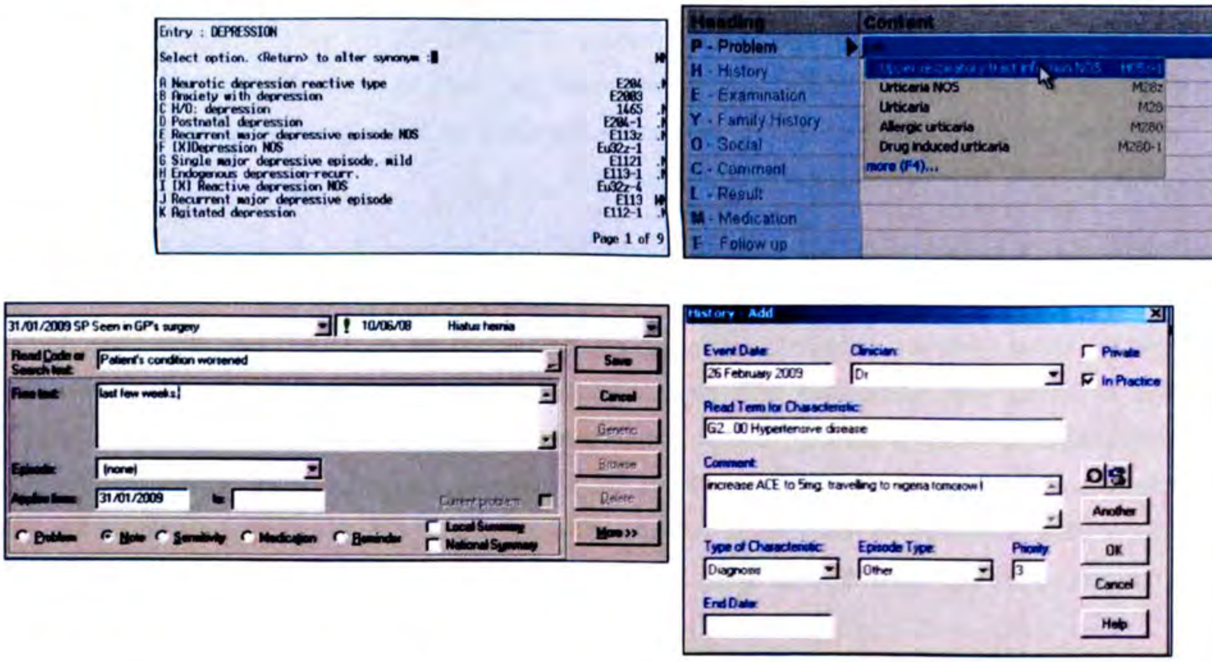


Figure 7.17 *:* Most commonly used coded data entry interfaces in LV, PCS, Vision and Synergy systems (clockwise).

7.4.1 Coded data entry – LV

Isolated, text links and character key based code selection

LV users initiated their code entry process by moving through the set of text links in the bottom of the default consultation screen, often using navigation keys. They first had to select the 'problem title' to initiate the code searching process, at which point they were taken to a separate page. The *code search* page only has a single input field to type the search term, the matching Read terms and associated codes are shown underneath. During the code searching process user is completely divorced from any data entered thus far in the consultation or any of the patient summary information. A message stating 'Read spelling not recorded' appears next to the input field once three characters of the search term is entered, and stays until the complete word is typed in. Doctors then pressed the enter key, which prompts the system to present the picking list. Selection of the relevant item has to be done by pressing the character key indicated in front of the Read term; doctors first have to recognise the correct term then identify the associated character key. Selection of the desired term records it into the ongoing consultations record, in front of the heading 'problem title'.

When adding a problem title, the LV interface additionally prompts the user to select the problem type; to specify as minor or significant and the type of episode; as first, new or review. Both these selections have to be done by typing a corresponding character key.

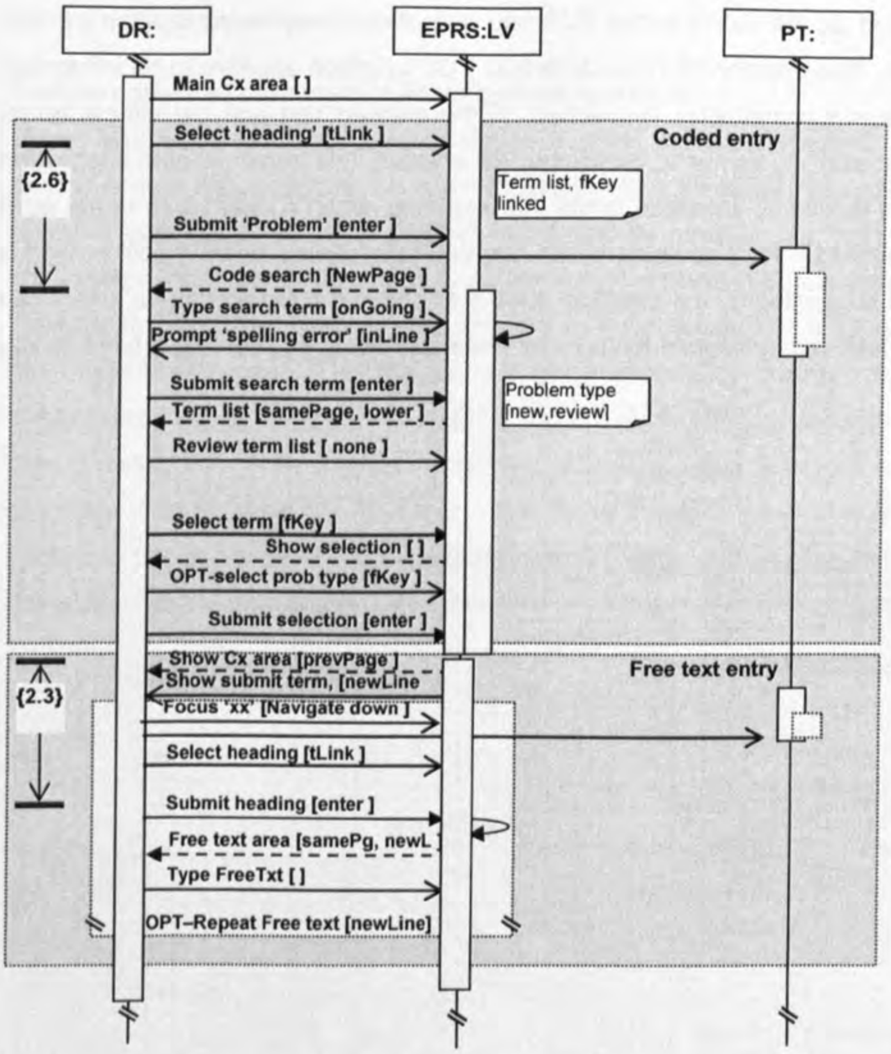


Figure 7.18: Process model of coded and free text data entry in LV

7.4.2 Coded data entry – PCS

'auto suggestion' based integrated code selection

Doctors used a semi-automated coded entry process offered in the PCS interface to move between coded and free text entry with minimum effort. PCS interface deploys a text suggestion strategy, also known as *auto-completion* techniques to analyse text as doctors enter them, examine them against the coding system and offer a list of matching terms. Its objective is to enable doctors to consider the possibility of capturing the information as they type in, into coded items which have more secondary usage which would have otherwise recorded as narrative text. As a result, there is a list of coded items appearing as a drop down list with multiple items for every word that is being entered. These code lists appear usually after user has entered the second character of the new word.

There are two coding patterns visible during the PCS coded entry process. There were situations where doctor planned to enter coded item, and typed in the appropriate term into the text entry area, anticipating the system to offer a list of matching codes. The other type is an opportunistic coding pattern, where doctors continue with their narrative data entry, and if they noticed a suitable prospect for coding based on the list of terms PCS has suggested, they evaluated the list and selected a suitable code. The creation of the code lists in PCS interface appears to be influenced by the similarities between the character sequences, of the entered text and the clinical terms instead of based on key word or semantic meanings. As a result, this constant auto-suggestion process frequently offers groups of unrelated terms. For example, when a user types in the word 'had', the picking list offered by PCS contains terms ranging from 'altered bowel habit' to 'had a chat to parent'. If the list suggested by the interface does not contain the required code, users can activate a separate interface with advanced features for code searching; by pressing a function key (F4).

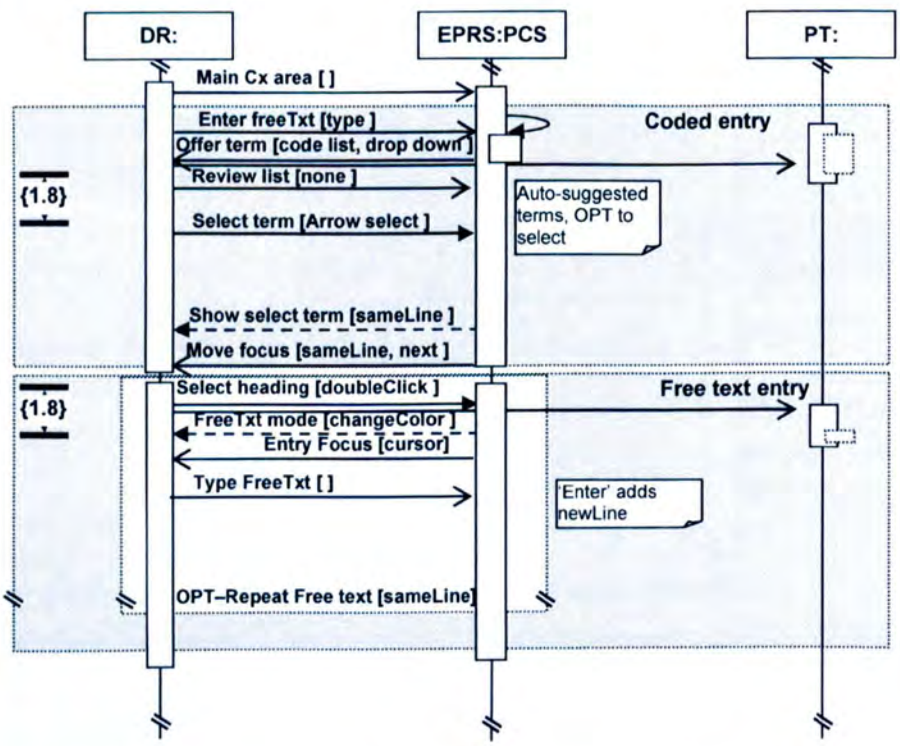


Figure 7.19: Process model of coded and free text data entry in PCS

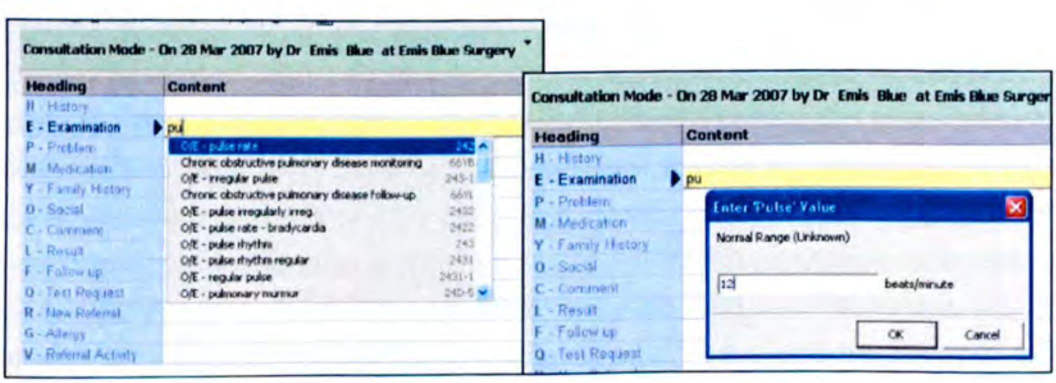


Figure 7.20: 'auto-suggestion' feature in PCS. Typing 'pu' presents the data entry form to enter pulse rate

7.4.3 Coded data entry – Vision

Problem oriented data entry with embedded interface

Coded data entry leads the data recording process in Vision systems. The Vision interface for adding patient history states the need for supplying a structured data item before supplying any narrative data. Data recording process is initiated by pressing the 'add history' icon in the main consultation interface. Options also exist to initiate the same interface using function keys or via the main menu. The data entry interface would then be presented as a sub window embedded to the main consultation page. This maintains a close association between the data entering and the existing sections of the patients' medical record; users are not taken away from the contextual data. Vision's data entry interfaces has two main text input areas; for coded and free text data. They are accompanied by six other input fields three of which are drop down lists and two additional check boxes. All those are pre-populated by default data and are intended to act as descriptors for the data entering task.

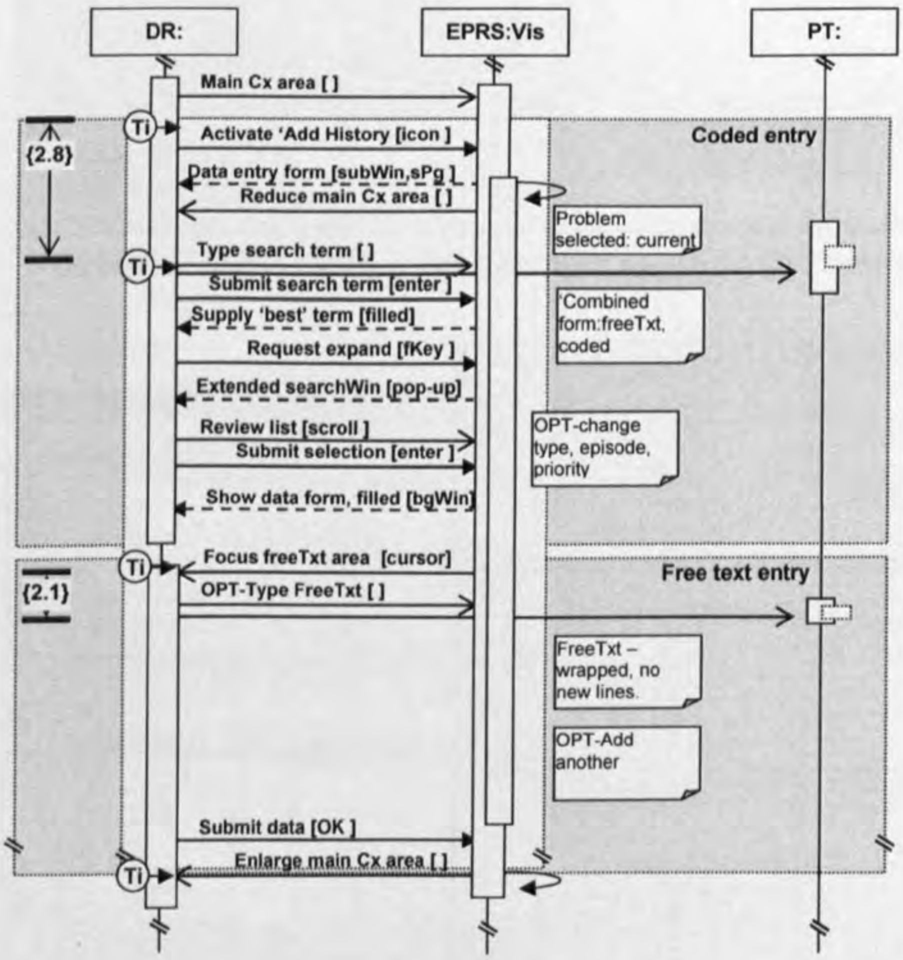


Figure 7.21: Process model of coded and free text data entry in Vision

Vision users first typed in the search term into the text input field and pressed the enter key to obtain a matching clinical term from the Read classification. The input field shows the most matching Read term. Vision users in most occasions opted to view a list of matching terms, and pressed a function key to open a separate pop-up window for code searching. This overlying window presents the full picking list, using which doctors can select the desired code or search further. For example, entering ‘depression’ as the search term selects ‘Endogenous depression – first episode’ as the preferred term, doctors who wanted to have ‘Depressive disorder’ found it as the fourth item in the picking list shown in the second interface. Selection of a coded item automatically takes the user into the free text entry area. Two of the drop down lists in the data entry interface allows the users to select the characteristics and episode type, which were never interacted with by the Vision users in the study sample. To store the entered coded and free text elements, Vision users have to press on the ‘OK’ button using the mouse pointer, which closes the data entry sub-window.

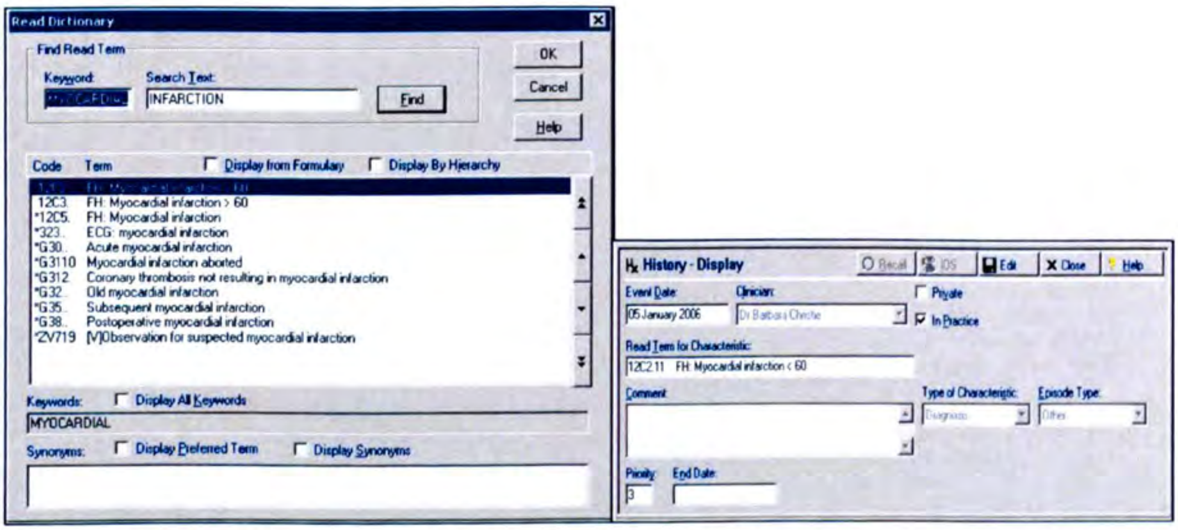


Figure 7.22: Data entry interface in Vision, and extended search function offered in a separate pop-up window.

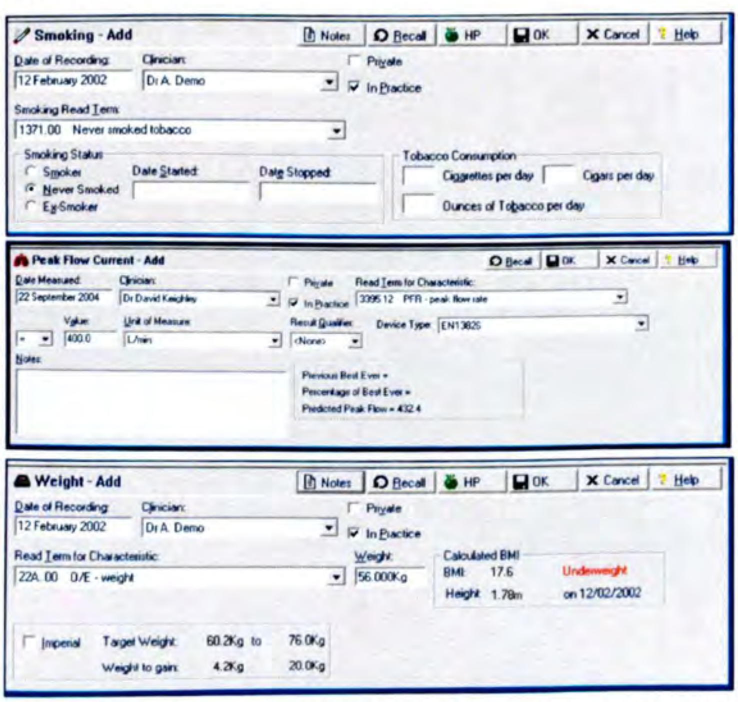


Figure 7.23: Customised data entry forms offered in Vision for commonly entered coded data items; smoking status, peak flow readings and weight.

7.4.4 Coded data entry – Synergy

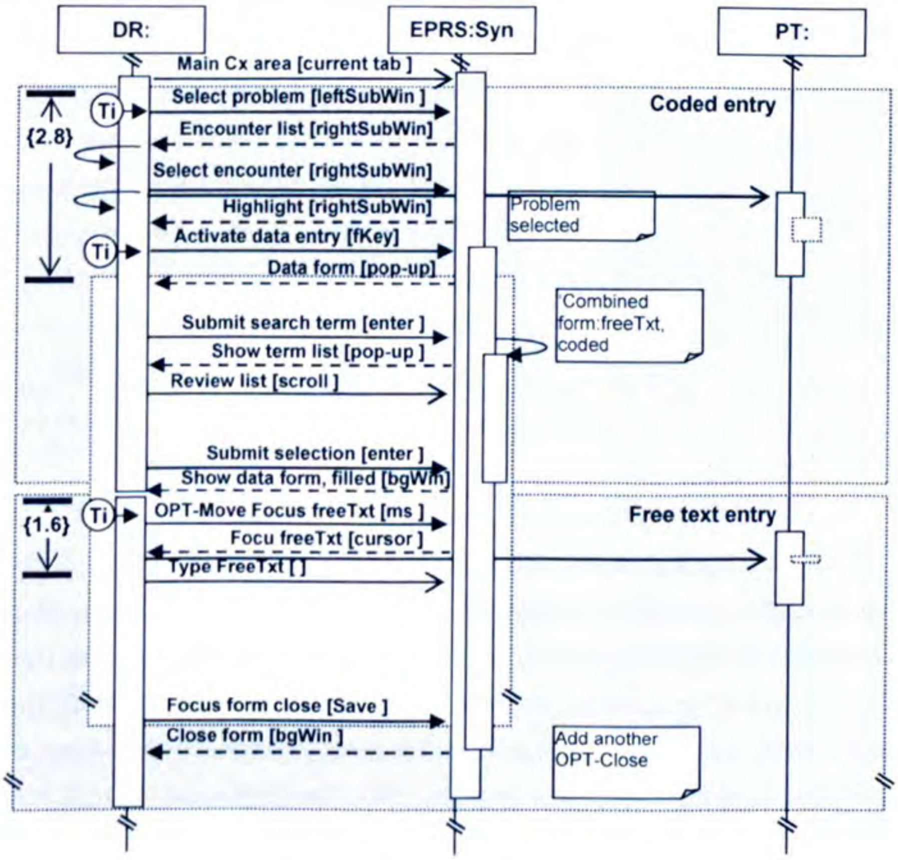


Figure 7.24: Process model of coded and free text data entry in Synergy

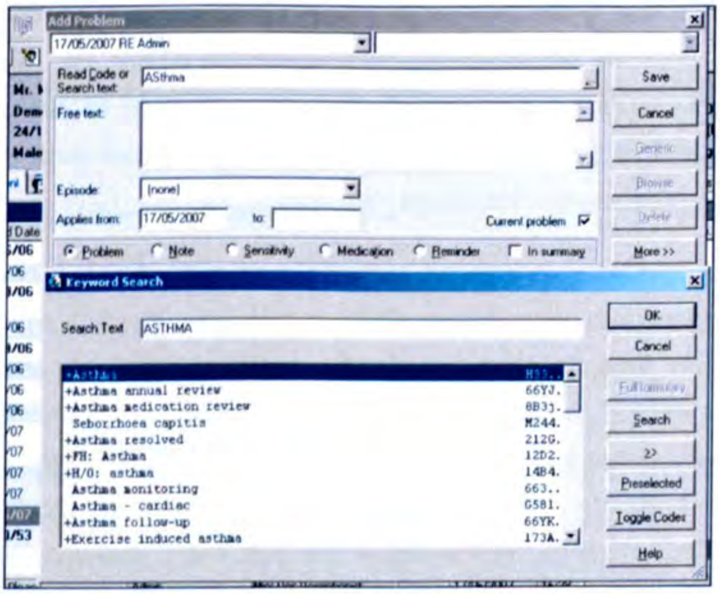


Figure 7.25: Data entry interface in Synergy, and extended search function offered in a separate pop-up window.

Figure 7.26: Customised data entry form for recording height and weight in Synergy. Patients reported their weight in 'St' instead of in 'kg', forcing doctors to try entering different values until the correct conversion is achieved.

Strict problem orientation with multiple pop-up windows

Synergy enforces a strict problem orientation strategy in its data entry process. Unlike Vision, Synergy users have to actively link all free text entry episodes to a coded entry. Doctors using Synergy performed their data entry in the 'current' tab within the main consultation interface. They first selected the problem which has been the topic of the ongoing consultation from the chronologically ordered problem list in the left hand side panel. They then clicked on the right hand side panel to indicate the intended data entry as a new topic under the same problem or to link with another existing topic.

After performing this double selection, Synergy users clicked on a function key to initiate an instance of the data entry pop-up window. This interface would be having the details of the current session and the problem title already indicated. Users then would type in the search term into the first input area and press entry, which opens the second pop-up window with the picking list. This second window offers the result of a keyword based search, and has advanced features to narrow down the code selection process. Selection of the looked-for clinical term takes the user back to the first pop-up window and places the selected item in the coded data area.

After selecting the coded item, doctors moved onto entering narrative data using the text box element provided underneath. This interface also offers the possibility to categorise the data entry under five possible headings; as problem, note, sensitivity, medication and reminder using radio buttons. 'Note' category is selected by default. Another check box element allows the doctor to indicate whether that particular data entry should be placed under the medical record summary or not, this option is also selected by default. None of the synergy users in the study sample interacted with those two sets of interface elements. At the end of the data entry, pressing the 'enter' key would store the entered data and resets the data entry interface. This allowed the users to start a new cycle of data entry for the same problem title. Users have to press the 'close' button in the data entry interface to close the pop-up window and to move back to the main consultation area.

7.4.5 Altering between coded and free text data entry

Coded-free text altering - LV

Text link based structured recording

After adding a coded item in LV, cursor is placed next to the Read term and doctors then often selected another consultation heading from the set of text links and continued entering free text. Adding a line break is not straightforward in LV data entry area. Doctors who wanted to organise the free text into an easily readable structure adopted the strategy of selecting the same consultation heading again to move the cursor into a new line; they pressed enter at the end of the existing sentence, moved back to the set of text links and selected the same heading again.

Coded-free text altering – PCS

Structured recording with integrated coded data

PCS users structured their data entry, making use of thirteen different consultation headings that are available. They combined coded and free text entries, as they entered data between different consultation headings; coded entries could be visually differentiated by their bolded text. To initiate a data entry under a specific consultation heading, users have to 'double click' on the associated input field; PCS interface acknowledges this by changing the background colour of the input area.

Coded-free text altering - Vision and Synergy

Problem oriented free text

Entering a coded item in Vision interface takes the users into the free text entry interface by default. Doctors can start entering free text right away. In contrast, Synergy users always have to point the mouse pointer and click on the text box to instigate the narrative data entry process, if not pressing the 'enter' key immediately after coded data entry would close the data entry sub window. Both in Synergy and Vision interfaces, line breaks can not be introduced into the free text.

7.4.6 Number of coded entries

A close relationship between the coded and free text entry means, in Vision and Synergy consultations doctors were compelled to select a coded item, whilst they attempt to enter narrative data. There is a significant difference between the mean numbers of coded items per consultation between the EPR systems (p=0.001). Doctors using LV and PCS seem to enter about two Read coded during a consultation (LV: mean=1.5, SD=1.5, PCS: mean=1.6, SD=1.5), while Vision and Synergy users record three codes per consultation (mean=2.9 for both, Vision:SD=2.4, Synegy:SD=2.6). Proportionately, Vision and Synergy had fewer consultations with no coded entries, and higher proportions when an occurrence of multiple coding is concerned. Consultation conducted with LV represents the largest proportion with no coded entries (n=16/57, 28.1%). Both Synergy and Vision had lower proportions of consultations with no coded entries; only one Vision consultation (n=1/40, 2.5%) while only 10% (n=3/30) of Synergy did not have a coded data entry. There were three consultations each with Synergy and Vision, where more than five coded items were recorded (7.5% and 10% respectively), while only single LV consultation had a similar coding rate and none were reported with PCS.

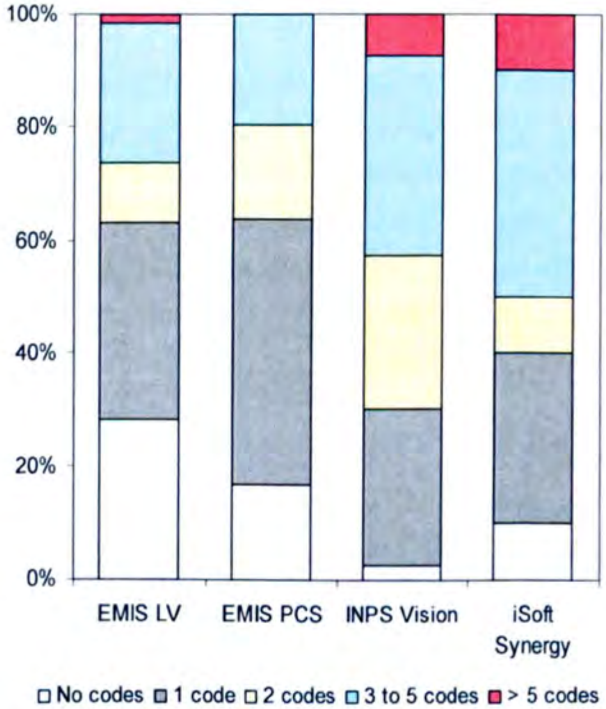


Figure 7.27: Proportion of the consultations based on number of items coded, by EPR system

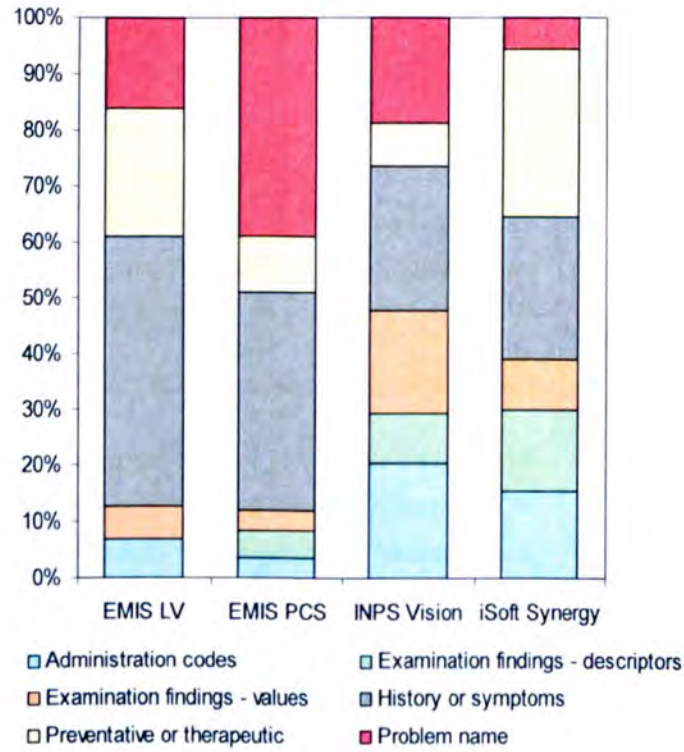


Figure 7.28: Proportion of the consultations based on the type of items coded, by EPR system

	Consult-ations N	Number of codes entered during a consultation									
		No coding		1 code		2 codes		3 to 5 codes		> 5 codes	
		N	N%	N	N%	N	N%	N	N%	N	N%
LV	57	16	28.1	20	35.1	6	10.5	14	24.6	1	1.8
PCS	36	6	16.7	17	47.2	6	16.7	7	19.4	0	0.0
Vision	40	1	2.5	11	27.5	11	27.5	14	35.0	3	7.5
Synergy	30	3	10.0	9	30.0	3	10.0	12	40.0	3	10.0

Table 7.4: Number of coded entered by EPR system

7.4.7 Time taken for coded entry initiation and code selection

Consultations with PCS reported the lowest mean duration for a coded data entry interaction (mean=5.6s, SD=3.4s). Both LV and Vision has similar durations, which is more than two seconds longer than the mean duration of PCS (LV:mean=9s, SD=6.1s, Vision: mean=8.8s, SD=3.9s). Both are significantly different from PCS ($p<0.001$). Synergy has a mean duration of seven seconds (S=3.9s), which is also significantly different from those reported with LV and Vision, $p=0.014$ and $p=0.02$ respectively.

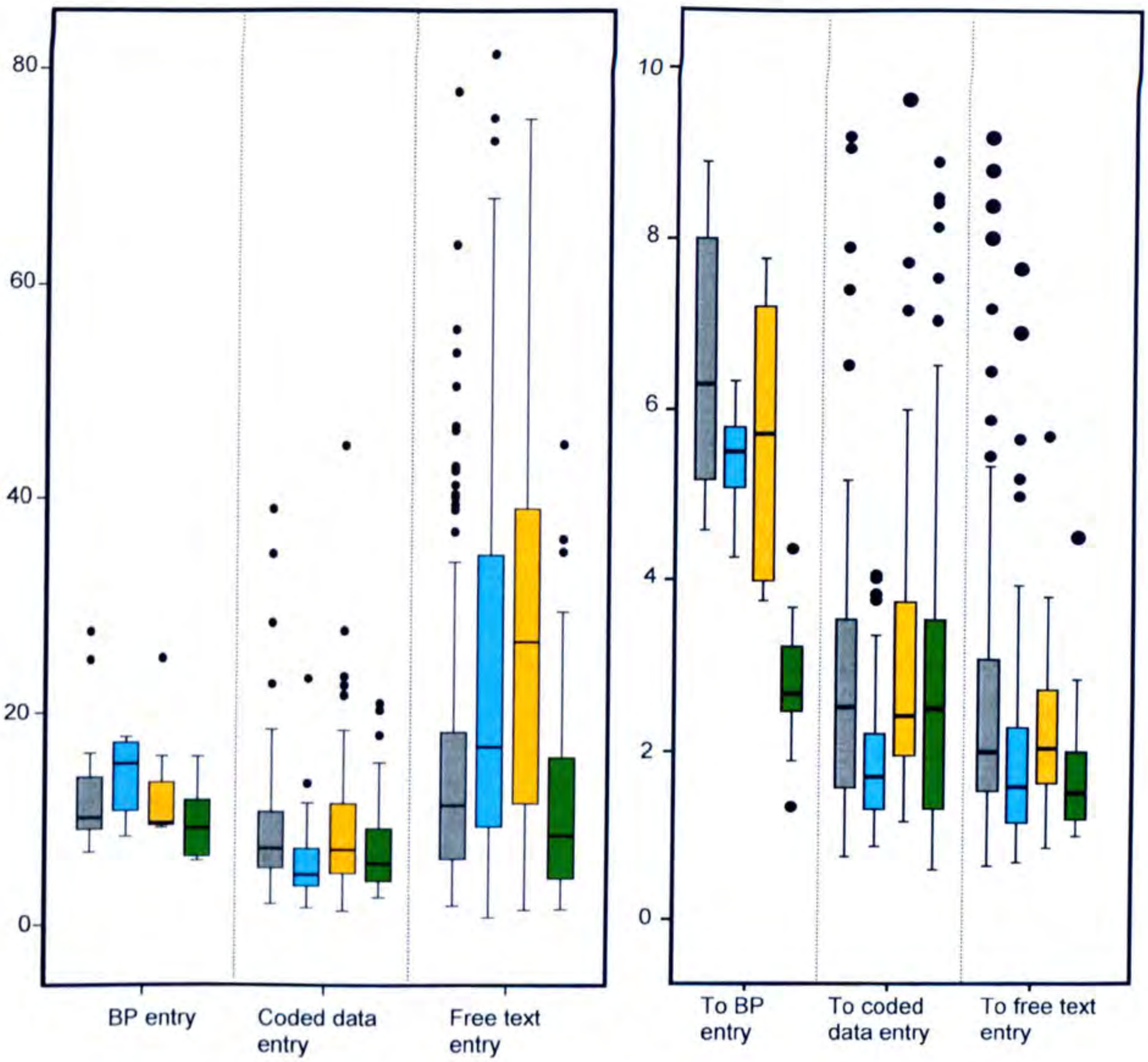


Figure 7.29: Box plots representing the time spent on data entry tasks and for their initiations. (EPR systems are in the order of LV, PCS, Vision and Synergy)

PCS users spent less than two seconds to initiate a coded data entry interaction (mean=1.8s, SD=0.8s) due to the 'auto suggestion' feature offered by the interface. In comparison, other three systems have mean transition durations that are nearly three seconds long (mean=2.8 for LV and Vision, mean=3.0 for Synergy). This difference between PCS and rest of the systems in the study sample is significant (p=0.005).

Auto completion feature offered by PCS appear to have enabled PCS users to achieve a faster coded data recording interaction. However, in number of occasions this approach resulted in introducing additional searching time. For example, when attempting to record 'smoking cessation counselling', no appropriate results were offered by PCS for doctors that typed 'smok' as the search term. The offered picking list mostly contained codes representing 'smoking status'. In such situation doctors eventually activated a separate code searching interface, which in fact lengthened the total interaction time. Even within this dedicated code search interface, only typing in the search term 'cessation' offered the appropriate Read code. Doctors that entered search terms 'smoking' or 'counselling' were faced with similar situations.

7.4.8 Distribution of coded data entry interactions in consultation timeline

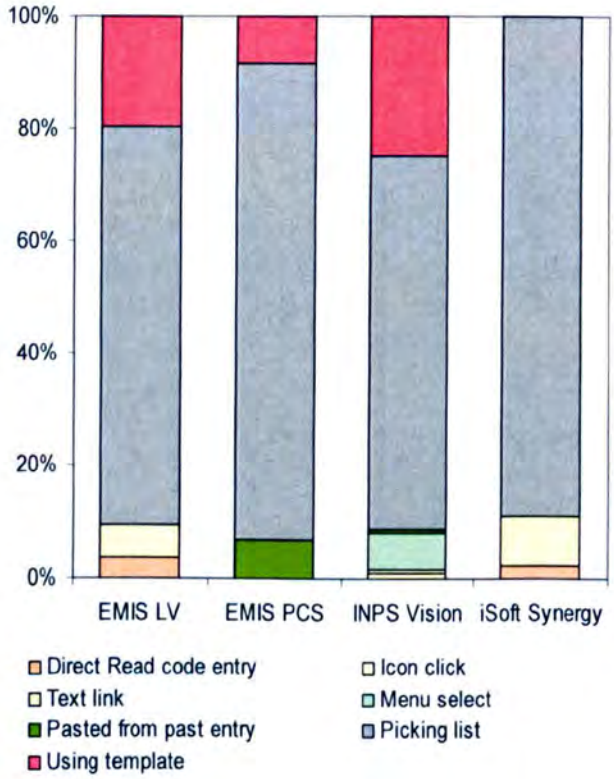


Figure 7.30: Proportion of the consultations based on the method used for coded data entry, by EPR system

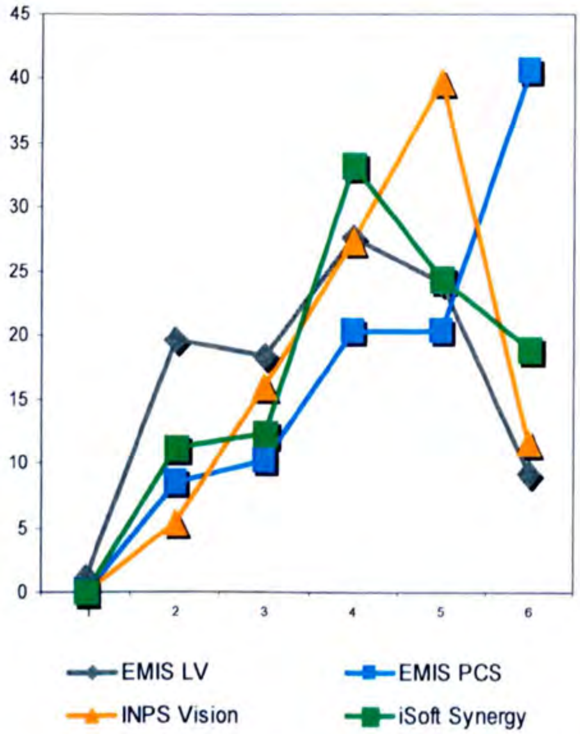


Figure 7.31: Distribution of coded data entry tasks across the consultation length (1-initial marginal, 2 to 4 = 1st to 4th quartiles of the core consultation. 6=final marginal consultation)

The proportion of coded entries in PCS gradually increases from the initial marginal to final marginal consultation, while other three systems have their coding interactions concentrated in second half of the core consultation. Occurrences of coded entries have similar patterns in all four systems up to the third quartile of the core consultation. More than half of the coding in all systems, except PCS has occurred in the second half of the core consultation. Proportion of coded entries of PCS continue to increase into the final marginal consultation (40.7% in final marginal), where as frequency of coding in other three systems have decreased after the core consultation (all less than 20%). The ease of coded entry initiation might have possible allowed the doctors to adopt an innate style of coding; where coded entries are performed as the objectives and outcomes of the consultation becomes clearer as the time progresses.

	Distribution of coded data entry task						
	Episodes N	Initial-marginal (N%)	Core Q1 (N%)	Core Q2 (N%)	Core Q3 (N%)	Core Q4 (N%)	Final-marginal (N%)
LV	87	1.1	19.5	18.4	27.6	24.1	9.2
PCS	59	0.0	8.5	10.2	20.3	20.3	40.7
Vision	113	0.0	5.3	15.9	27.4	39.8	11.5
Synergy	90	0.0	11.1	12.2	33.3	24.4	18.9

Table 7.5: Distribution of coded data entry tasks across the consultation length, by EPR system

7.4.9 Type of codes used

Symptoms, problem titles and recording of preventative actions were frequently recorded in LV and PCS systems, remaining categories (administration codes and examination findings) represent about 13% of coded entries in both those systems. In Synergy and Vision those categories represent about 40% of coded data entries. Users of those two systems have recorded more than double the amount of coded data entries representing patient administration related activities compared to LV and PCS users.

7.4.10 Fastest coded entry interactions

Minimum durations recorded in all four systems ranged between 1.3-2.6 seconds. In Vision consultations, the minimum duration (min=1.27s) occurred in a situation where doctor clicked on an icon to while following through an UTI examination guidelines screen, to record 'ENT examination NAD'. The fastest PCS data recording was 1.57s for recording patients smoking status by searching for the term. Minimum durations for LV (min=2s) and Synergy (min=2.58) were recorded while entering the codes for ex-smoker' and 'discussion about disorder' respectively.

7.4.11 Method of code entering

Searching the Read code dictionary using an appropriate term and selecting the most representative item from an offered list of code labels is the commonest. This is available in all four systems, and has accounted for 76.3% (267/355) of total coded data entries of the sample.

Directly typing in the Read code value is also possible in all four systems. However this was only used in total of five occasions; three entries in LV and two in Synergy. Typing in the Read code directly requires least amount of doctor-computer interactions. However, doctors in fact spent longer durations entering and correcting the code value; the fastest and the slowest code entry using this method were 5.2 and 7.5 seconds respectively. This was more than double the observed minimum durations across all four systems.

PCS and Synergy provides facilities to copy problem titles from previous entries and paste them into new episodes of data entry. Systems with graphical user interfaces use icons to provide access to frequently use functional features. Some are allocated for data entry operations.

Copying from past coded entries and pasting them into the current consultation was observed in four occasions in consultations with PCS. On those occasions, doctors copied the problem titles from the summary data sub-window and pasted in the main consultation data entry window.

Nine coded items were entered by clicking on icons, out of which eight occurred in Synergy. They represent codes associated with 'smoking status', 'BMI values' or 'alcohol consumption'. Compared to the methods available for coded data entry in Vision, going through the main menu of the consultation interface requires the most number of interactions However, this was used eight times by Vision users (6.7%). This method was not observed in consultations with other three systems.

7.4.12 Recording of non-specific codes

Though the problem oriented data recording strategies could promote coding of information, they could also result in capturing of non-specific codes, if the code selection was merely done as an enabler for entering free text. The underlying functionality of the data entry interface available in Vision or Synergy is not capable of recognising any associations with the selected code and the meaning of the entered free text. Maintaining a rational association between the two data entry elements remain as a responsibility of the user. Implementation of this problem orientation strategy appears to have contributed to the increased number of coded data entries in these two systems. This is particularly noticeable in Synergy, where this association is strictly implemented. It is also interesting to note that Read codes representing the terms 'discussion about disorder' or 'had a chat with a patient' were recorded 19 time by Synergy users, this represents 21% (19/90) of total number of items coded.

7.4.13 Promotion of block user style interactions

When entering coded data using the 'picking list' methods in succession, Synergy and Vision users have to perform the interactions for activating the 'code search' interface only for the first data item. Subsequent data items can be entered easily.

7.4.14 Blood pressure data recording – LV

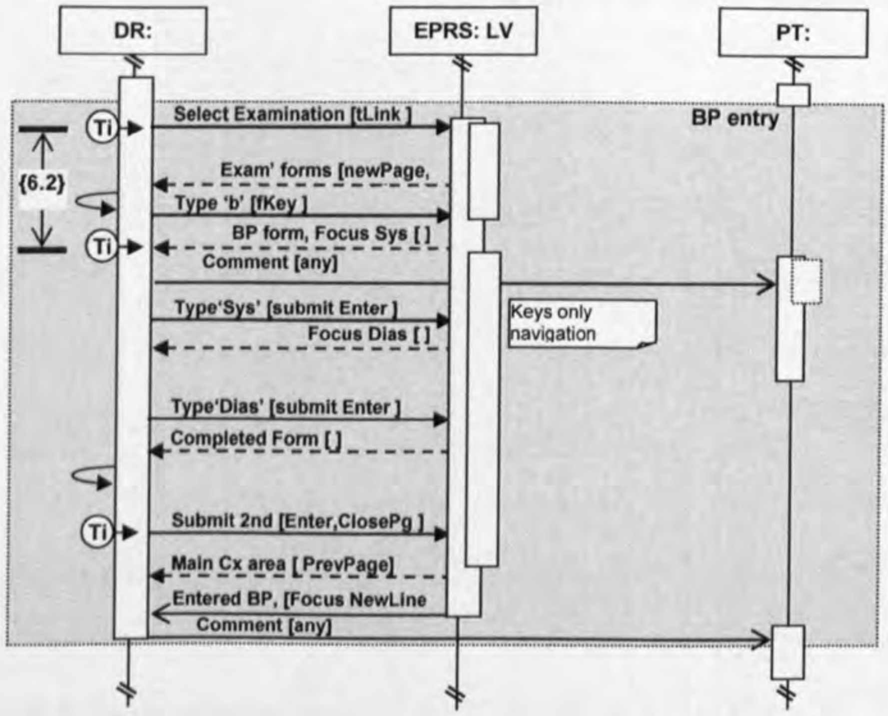


Figure 7.32: Process model of blood pressure data recording in LV

Character based initiation with isolated input fields

LV users initiated the blood pressure data recording process by selecting the text link for 'Examination' from the main navigation, which presents a new page, away from the main consultation interface. This new interface has a list of commonly used examination data entry forms, a character key associated with each list item is also indicated. Doctors using LV system in the study sample typed the letter 'b' at that stage to invoke the blood pressure data entry form. The BP recording interface has the two data entry rows to enter systolic and diastolic readings; no unit of measurement is indicated at the beginning. The unit 'mmHg' appears only after entering the systolic reading. Users could move over to the diastolic input area just by pressing the 'enter' key after entering the systolic reading, the second pressing of the same key stores the blood pressure examination results and takes the user back to the main consultation area.

7.4.15 Blood pressure data recording – PCS

Auto suggested, informative data entry form

PCS auto-suggestion feature offers the BP data entry interface when doctors typed in 'bp' in the text input area. Although, the task initiation occurred rapidly, there is a delay in the appearance of the actual BP entry interface. PCS's blood pressure data entry form provided two useful pieces of information, while offering the two text input fields for systolic and diastolic readings; the previous systolic and diastolic readings together with the dates of their recording and the average blood pressure value based on all past readings. Units of measurements are clearly indicated in the interface. PCS users toggled between the two text fields by selecting with the mouse pointer or using the 'tab' key. Pressing the 'OK' key adds the two readings into the main consultation data entry area, next to the consultation heading for 'Examinations'.

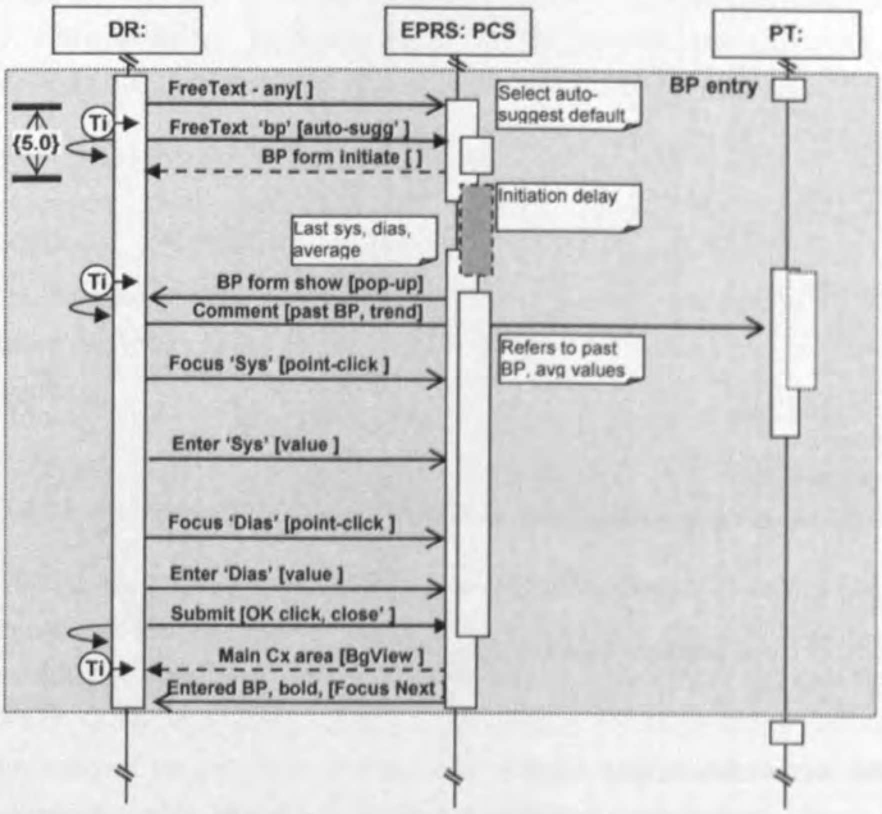


Figure 7.33: Process model of blood pressure data recording in PCS

7.4.16 Blood pressure data recording – Vision

Main menu based recording

Blood pressure recording is linked to the 'add item' option. Doctors using Vision either selected the option to 'blood pressure – add' by the use of main menu or by right clicking on a past blood pressure reading. Similar to the coded entry interface, blood pressure data recording interface is presented as an embedded sub-window in the main consultation interface. There are ten different text fields altogether. One has the read term for blood pressure reading as the default data item, two more text boxes represent the systolic and diastolic data input fields. Users have to either point and click or press the 'tab' key to move from systolic to diastolic input areas. Remaining input fields represent descriptors such as date, time, patient's position, and cuff details associated with the blood pressure examination process, all of which are pre-populated with default values. Pressing 'OK' button at the end of the data entering process removes the blood pressure recording interface and restores the main consultation view.

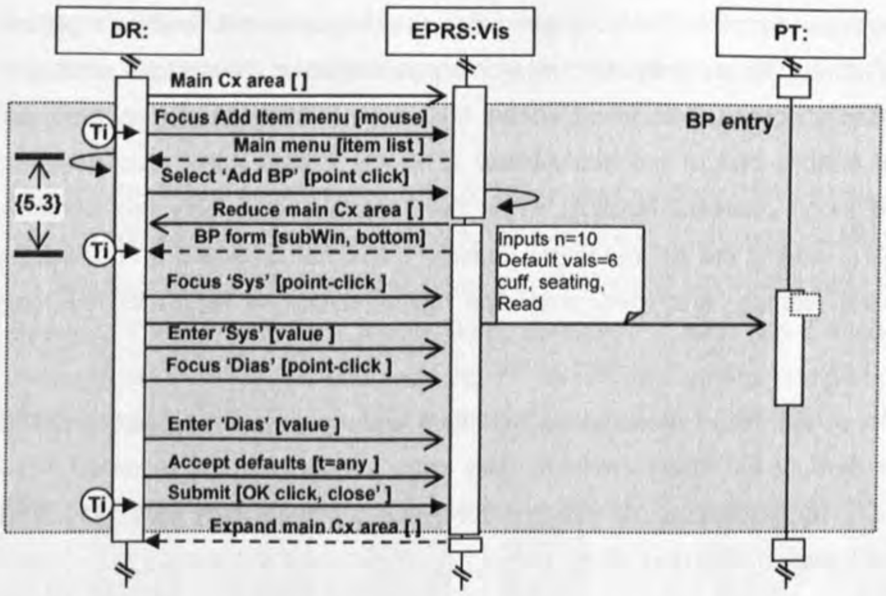


Figure 7.34: Process model of blood pressure data recording in Vision

7.4.17 Blood pressure data recording – Synergy

Two different interfaces initiated by dissimilar approaches

Synergy users have two dissimilar approaches for BP recording. The most straight forward approach is to click on the short-cut icon in the main navigation area, which directly presents a simpler sub-window for capturing BP readings. As with the coded data entry process, all BP readings are linked with the currently selected problem title. The BP recording interface shows the selected problem's Read term, and two small horizontally arranged text boxes to enter systolic and diastolic readings. There are two other data entry elements; a small text field titled as 'free text' allows users to enter any comments if needed, a check box labelled 'advised' can be used to indicate that patient has been advised about the BP reading. Selection of the check box in fact, adds the corresponding read term in to the patient record.

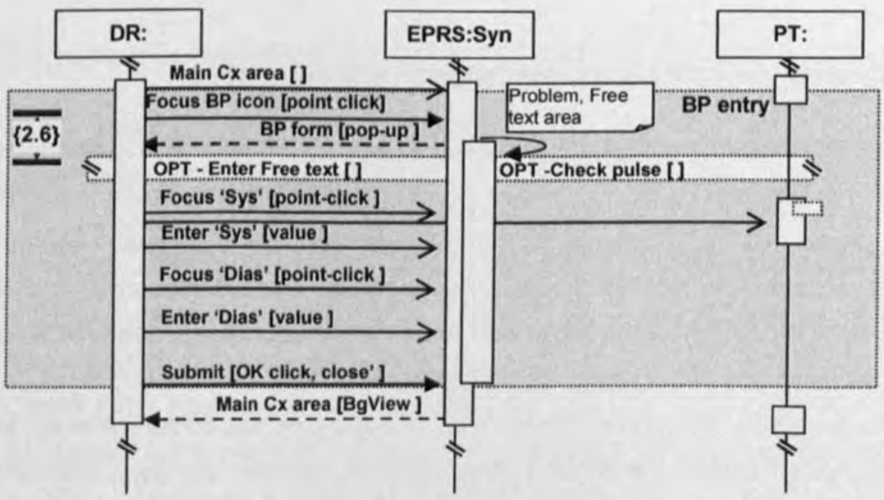


Figure 7.35: Process model of blood pressure data recording in Synergy

Doctors who followed the second method for blood pressure recording used the Synergy's generic data entry sub-window. Entering 'bp' as in the term search area recognises the doctor's attempt to supply BP readings, perform two activities; first it shows the 'o/e – BP reading' Read term, and secondly it changes the bottom part of the sub-window to reveal a data entry area designed specifically for accepting blood pressure reading. This new interface area only has vertically arranged two input fields to supply the BP readings. Synergy users had to select and press the 'Save' button to store the reading, and then press the 'close' button to return to the main consultation interface.

A total of 41 consultations had blood pressure examination and subsequent recording of the findings. More than one third of the blood pressure data entry interactions are recorded in LV consultations (n=15/41, 37.5%), while a quarter is from consultations with Synergy (n=10/41, 25%). Remaining are distributed between PCS and Vision in equal numbers (n=8/41, 20%).

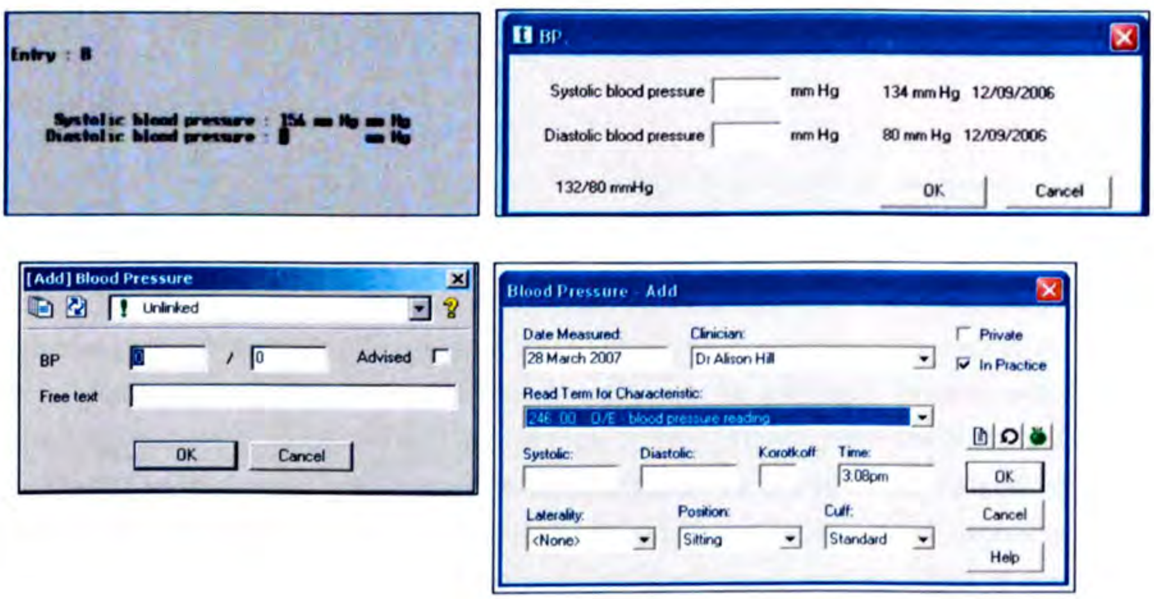


Figure 7.36: Blood pressure data recording interfaces in LV, PCS, Vision and Synergy (clockwise).

7.4.18 Time taken for blood pressure data entry task initiation and completion

Both the amount of time doctors took for initiating the blood pressure recording interface and total time for completing a blood pressure data recording have significant differences between the EPR systems. With a mean duration of 9.7 seconds (SD=3.4s), Synergy is the fastest. Though performed in a different manner, picking list based LV's approach for BP recording and a combination of methods used by Vision users have very similar mean durations; users of both systems spend about eleven seconds for recording BP values (mean=10.6s for both, LV; SD=2.7s, Vision; Sd=2.4s) The auto-suggestion technique offered in PCS recognises the doctor's attempt to record BP values and initiates presenting the BP recording interface, however the delay between the text recognition (usually initiated by entering 'bp') and interface presentation lengthened the actual coding time (mean=14s, SD=3.7s). Furthermore, in three instances (n=3/8) PCS users spent additional time gazing at the past recording values and average readings offered by the interface. The differences between the mean durations reported from each EPR system is significant (p=0.032), primarily caused by the divergence of PCS's BP recording time from the other three systems (PCS-LV; p=0.018, PCS-Vision; p=0.039, PCS-Synergy; p=0.005).

This shortest duration observed with Synergy could possibly be attributed to its fast transitioning time. to activate the simpler interface for BP recording. Icon based interface launching in Vision is the fastest (mean=2.6s, SD=0.8s). This is in fact nearly half of the next shortest initiation duration reported, which is with PCS (mean=5.0s, SD=0.6s). Vision has a slightly higher mean duration (mean=5.3s, SD=1.5s) for obtaining the BP recording interface compared to PCS, while LV's text link based approach is the slowest (mean=6.2s, SD=1.4).

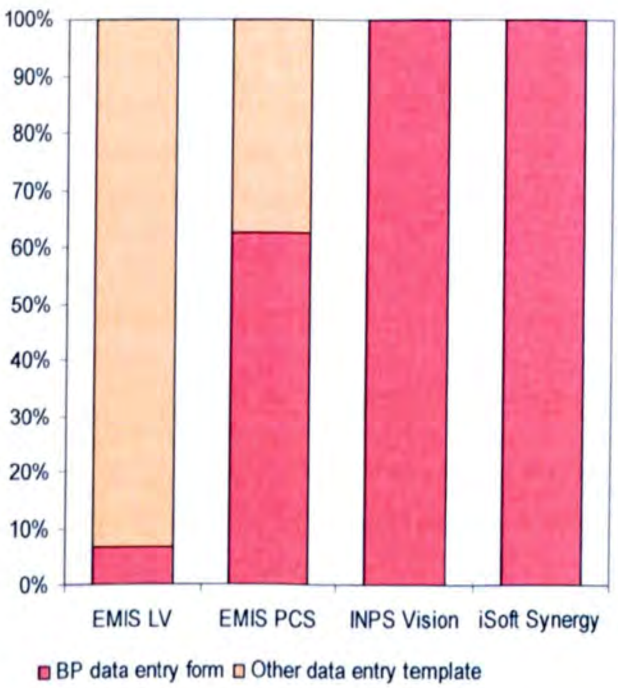


Figure 7.37: Proportions of the blood pressure recording incidents using two possible data entry methods, by EPR system.

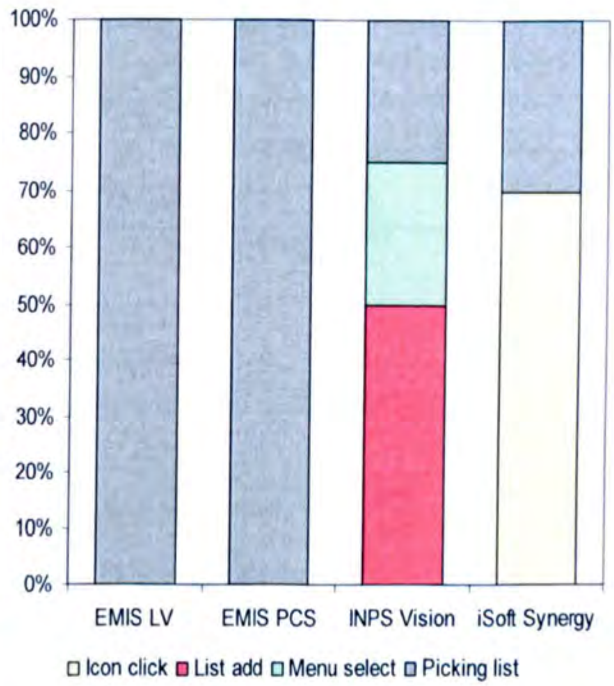


Figure 7.38: Proportions of the blood pressure recording incidents with different data entry activation methods, by EPR system.

7.4.19 Distribution of blood pressure data entry interactions in consultation timeline

Blood pressure recording interactions mainly took place in periods after the first quartile of the core consultation. Only LV users stored BP reading in the first quartile of the core consultation, and in fact, the largest proportion (n=6/15,40%) of LV's interactions with BP interface occurred in the *same consultation* period. Synergy's strict requirement for problem linkage most of the time influenced its users to perform block type data recording; *BP recording interactions* and most other data recording tasks occurred towards the end of the core consultation. As with the other types of Coded entry interactions, in PCS consultation the BP recording tasks represent a pattern less influenced by the interface, as with what earlier discussed on coded data recording. BP recording in PCS has occurred in equal proportions throughout the consultation segments subsequent to the core consultation's first quartile. Doctors using PCS system could easily move into the examination heading and instigate the BP recording process at any occasions amidst their free text entering process.

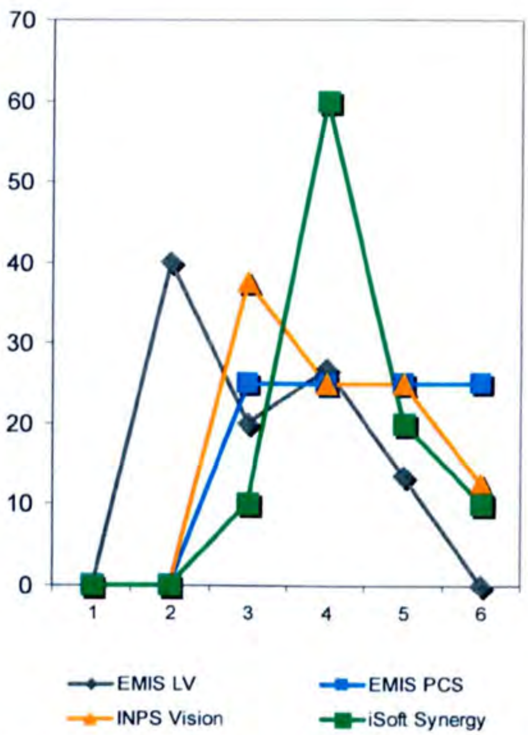


Figure 7.39: Distribution of blood pressure data entry across the consultation length.

	Distribution of blood pressure data entry task						
	Episodes N	**Initial-marginal (N%)**	**Core Q1 (N%)**	**Core Q2 (N%)**	**Core Q3 (N%)**	**Core Q4 (N%)**	**Final-marginal (N%)**
LV	15	0.0	40.0	20.0	26.7	13.3	0.0
PCS	8	0.0	0.0	25.0	25.0	25.0	25.0
Vision	8	0.0	0.0	37.5	25.0	25.0	12.5
Synergy	10	0.0	0.0	10.0	60.0	20.0	10.0

Table 7.6: Distribution of blood pressure data entry task across the consultation length, by EPR system

7.4.20 Fastest and longest BP entry interactions

The longest reported BP recording interaction is from a PCS consultation (17.8s), however this particular interaction has and overlapping doctor-patient verbal interaction which is in fact associated with the BP reading values. Similar to PCS, LV users also used a single method for activating the BP recording interface, and the maximum reported duration is 16.2 seconds. Longest durations from both PCS and LV systems are from instances where general health status monitoring templates have been used. Vision and Synergy have similar longest durations in the sample, 15.9 seconds. Longest reported from Synergy consultation is associated with a situation where doctor launched the BP interface using the sort-cut icon, nevertheless spent additional time entering a comment to the free text input area. The doctor deciding to go through the main menu's 'add item' list, looking up for the BP recording related option resulted in the longest BP recording interaction with Vision.

The fastest BP recording occurred in a Synergy consultation, taking only six seconds; the consulting doctor used the short-cut icon to launch the BP interface. The picking list based BP recording initiation approaches in LV and Synergy also have comparatively smaller minimum recording times (6.1s and 6.9s). The delay in interface loading means PCS consultation have a reported shortest duration of 8.4 seconds, which is in fact higher than LV's text link based and Synergy's pop-up window based approaches for offering picking lists. In situation where both BP data entry form and other data entry templates have been used in the same EPR systems, always the shortest durations are associated with the former method.

Three BP recording tasks; two from PCS and remaining from Vision had to be excluded from the analysis, due to the lengthened duration they had. They represented BP recording interactions undertaken using data entry templates, which were delayed due to doctor deciding to move into a different part of the data entry form.

7.4.21 Method of activation

All BP recording tasks in LV and PCS consultations occurred using picking lists, where doctors initiated the interaction by supplying 'bp' as a search term. Majority of the doctors using Synergy system used the short-cut icon to activate the BP recording process, while picking list approach was used in three occasions (n-3/10, 30%). In those three occasions, doctors already had the generic data entry interface initiated for entering coded data and they continued using the same to start the BP data recording. Three different initiation approaches were noted in Vision consultation; in most occasions doctors 'right clicked' on an existing entry to launch the BP recording interface (n=4/8), while picking list method and selecting from main menu approaches were used two times each. The decision to use the picking list approach could be justified considering the on goin data entry interaction in those two reported instances. In the two remaing situations, where neither the code searching sub-window, nor the list view of past BP was activated, vision users decided to go through the generic main menu to initiate a new BP entry task.

7.4.22 Data validation features

Both Vision and Synergy validates the values entered into the Systolic and Diastolic input areas. Synergy BP recording interface, in its extended view in fact displays the valid and expected value ranges. PCS interface lack any validation rules; if doctors accidently entered unusual readings or inserts a lower value for systolic system still accepts them into the patient record (e.g. systolic value of even 3000 mmHg could be entered). Synergy interface on the other hand prompted a doctor about the misplaced BP reading values by a pop-up message after changing the background colour of the incorrectly entered value.

7.4.23 Moving between systolic and diastolic input areas

The ease of moving from systolic to diastolic input area seems to have an influence on the total BP recording time. LV users easily moved onto enter the diastolic value due to the vertical arrangement of data entry areas and due to the fact that pressing 'enter' key after supplying systolic reading places the cursor in the diastolic input area. Efficiency gain in vertical arrangements is also visible in PCS interface and in situations where other data entry templates were used. Horizontal arrangement of BP value input areas, often prompted the doctors to use the mouse pointer to 'point and click' to move between the data entry fields rather than using key board based navigation. Use of mouse based navigation lengthened the interaction duration and is more demanding.

7.4.24 Use of generic data entry templates

Doctors used data entry templates designed for general health status monitoring, in 17 occasions to record blood pressure examination findings (n=17/41, 41.5%). Except in a single occasion where doctor entered both BP and smoking status data, in all other instances only BP values were entered into the template. Amongst the templates used by LV doctors, all had multiple pages and none contained the BP data entry fields in the first page; after launching the template doctors continuously pressed the down arrow to reach the BP input area. In data entry templates observed in PCS consultation though the form itself is a single data entry page, it is populated with large number of data entry fields; doctors spend considerable proportion of the time navigating through.

7.4.25 Summary of past readings

Doctors appear to find the past BP readings and average values for the patient presented in the PCS interface useful. In two occasions doctors referred to those values and commented on, comparing them with the latest observations. Obtaining similar historical data in any of system would require users to navigate into a separate examination findings area of the patient record, and additional interactions to filter and obtain a set of BP values. Extra time needed to obtain a similar set of historical information could range from 4.2 to 19.3 seconds (for LV, PCS, Vision, and Synergy the mean values are 8.8s, 8s, 4.25s, 19.3s respectively)

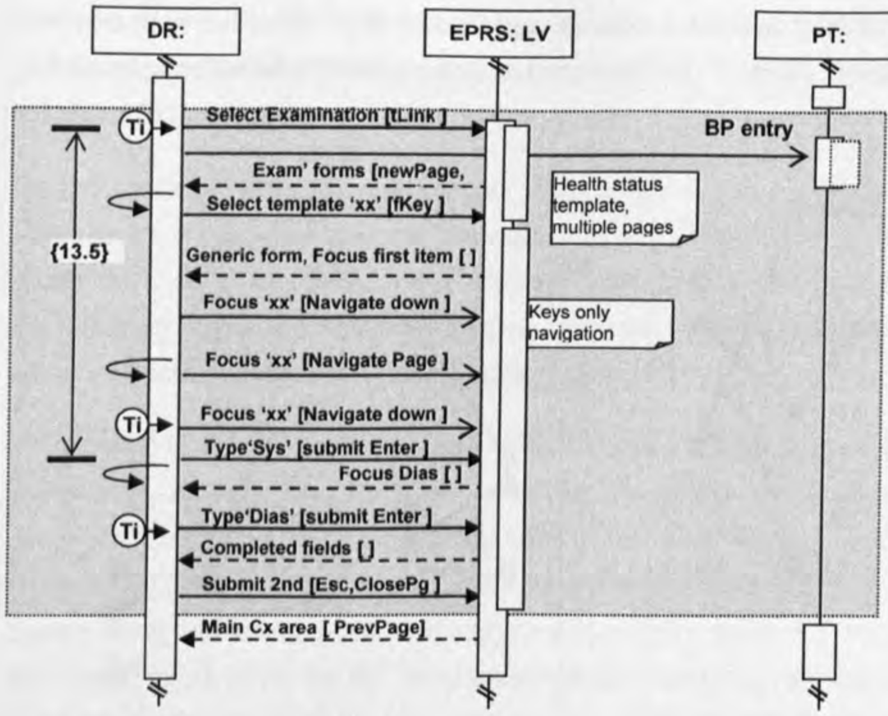


Figure 7.40: Process model of blood pressure data recording using a data entry form in LV

7.4.26 Influence of non-specific free text entry field

Synergy users either did not use the free text input areas provided in its BP recording interface, or used it in an inconsistent manner. In six out of the seven BP recording interactions performed using this particular interface, doctors did not interact with this free-text entry area. In one occasion this data entry field was used submit patient's the pulse rate. In a previous pilot study, it was seen used by a doctor to make a comment about a raised blood pressure reading.

7.4.27 Use of default values

Both Vision and Synergy have blood pressure recording interfaces with additional data entry fields. Vision interface attempts to capture a number of descriptors related to the examination process in addition to the time of and doctor involved in the examination process. All those additional fields are pre-populated with default values, and could be altered if needed. In all the observations involving those type of interfaces, none of the doctors interacted with the additional input fields, and it was not clear whether they reviewed the pre-selected values before submitting the BP readings.

7.4.28 Doctor-patient interactions during data entry tasks

Doctors verbally interacted with their patients for about 10.5% (SD=13.3%) of the overall data recording task durations, and they also made efforts to make eye contacts in about 3% (SD=5.6%) of the total length. Doctor-patient interactions were at their lowest during free text data entry; 14.9% and 5.5% proportion of the doctor-computer interaction length overlapped with verbal and eye contact respectively. Doctors mostly looked at the keyboard or at the screen when they recorded narrative data. In three different occasions doctors wrote-aloud; they verbalised what they were typing in the free text data entry field. Those instances were observed with two different doctors.

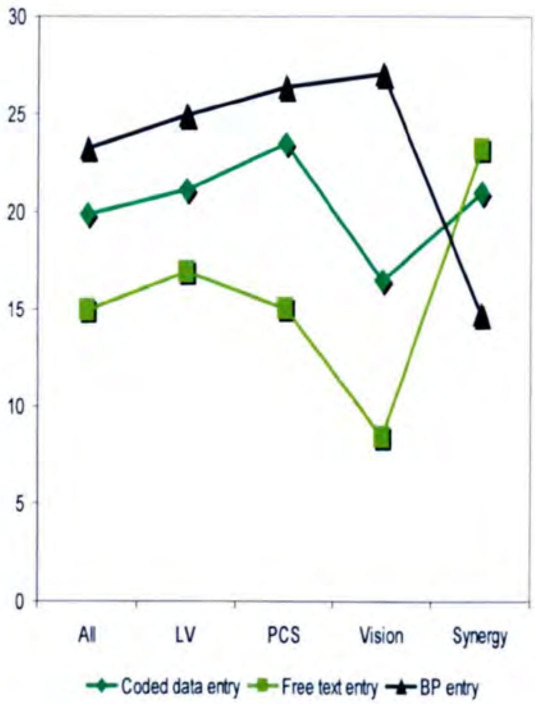


Figure 7.41: Proportion of data entry tasks with verbal interactions, by EPR system

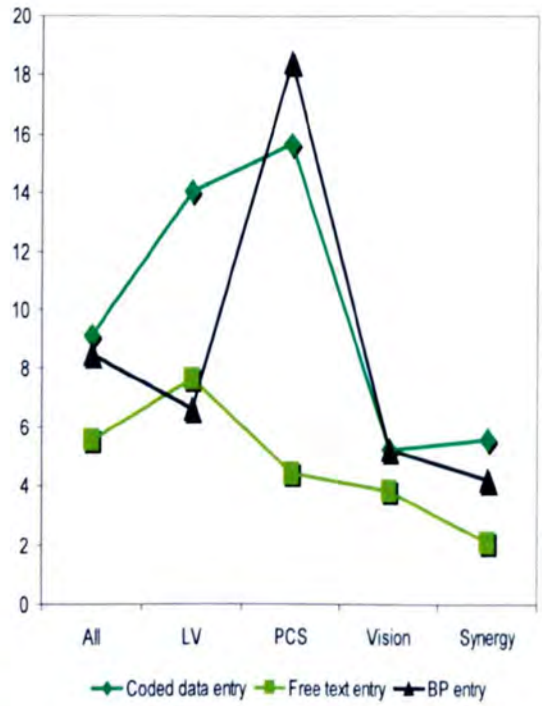


Figure 7.42: Proportion of data entry tasks with eye contact, by EPR system

		Computer use task								
		Coded data entry			Free text entry			BP entry		
		Cx N%	Mean (t%)	SD (t%)	Cx N%	Mean (t%)	SD (t%)	Cx N%	Mean (t%)	SD (t%)
All	**Verbal**	60.3	19.8	17.6	59.2	14.9	16.4	77.5	23.3	16.3
	Eye	30.1	9.1	13.8	46.1	5.5	5.3	32.5	8.5	9.8
LV	**Verbal**	68.3	21.1	18.5	58.9	16.9	16.8	86.7	24.9	16.4
	Eye	29.3	14.0	22.8	53.6	7.6	6.3	33.3	6.6	7.0
PCS	**Verbal**	36.7	23.5	18.6	58.8	15.0	15.4	62.5	26.4	20.0
	Eye	16.7	15.7	12.1	55.9	4.4	3.9	37.5	18.4	15.9
Vision	**Verbal**	69.2	16.5	13.1	64.1	8.4	8.3	75.0	27.1	19.3
	Eye	43.6	5.2	4.7	46.2	3.8	4.0	12.5	5.2	.
Synergy	**Verbal**	61.5	20.9	22.5	52.2	23.2	24.7	77.8	14.7	10.1
	Eye	26.9	5.6	4.2	13.0	2.1	2.4	44.4	4.2	3.9

Table 7.7 Verbal interactions and eye-contact during data entry tasks, by EPR system

Coded data entry in PCS consultation had the largest proportion of overlapping doctor-patient interactions. The 'auto-completion' approach in PCS placed less demands on doctors for both coded data entry initiation and when interacting with picking lists. Doctors needing to interact with extended code search windows or navigating through multiple picking lists views in Synergy and

Vision interfaces allowed little room for eye contact episodes. Proportions of eye contact in Vision and Synergy consultation during coded data entry is less than 6% compared to mean proportions of LV and PCS, which are more than 14%.

Doctors verbally interacted with patients more when adding new problem terms. Compared to Vision users, those interacting with the data entry interface of Synergy could use the 'enter' key to obtain the picking list, to submit a selected code and to initiate adding another coded item. Consequently, Synergy users have longer durations of coded data entry tasks overlapping with verbal interactions than Vision (20.9% compared to 16.4%).

Interactions aimed at blood pressure data recording mostly happened immediately after the examination process. Doctors often continued interacting with patients even while using the computer. Except the doctors using the Synergy interface, where blood pressure recording took place mostly in an extended version of the generic data entry interface, all other users spent nearly quarter of the data entering time verbally interacting with the patients. Those using PCS particularly had larger proportions of BP data entering task occurring in parallel to the doctor-patient interactions. The amount of eye contact was particularly high amongst PCS users; 18.4% compared to the next highest of 6.6%. PCS users also utilised the additional information offered by the BP recording interface to make comments to their patients.

7.5 Prescribing tasks

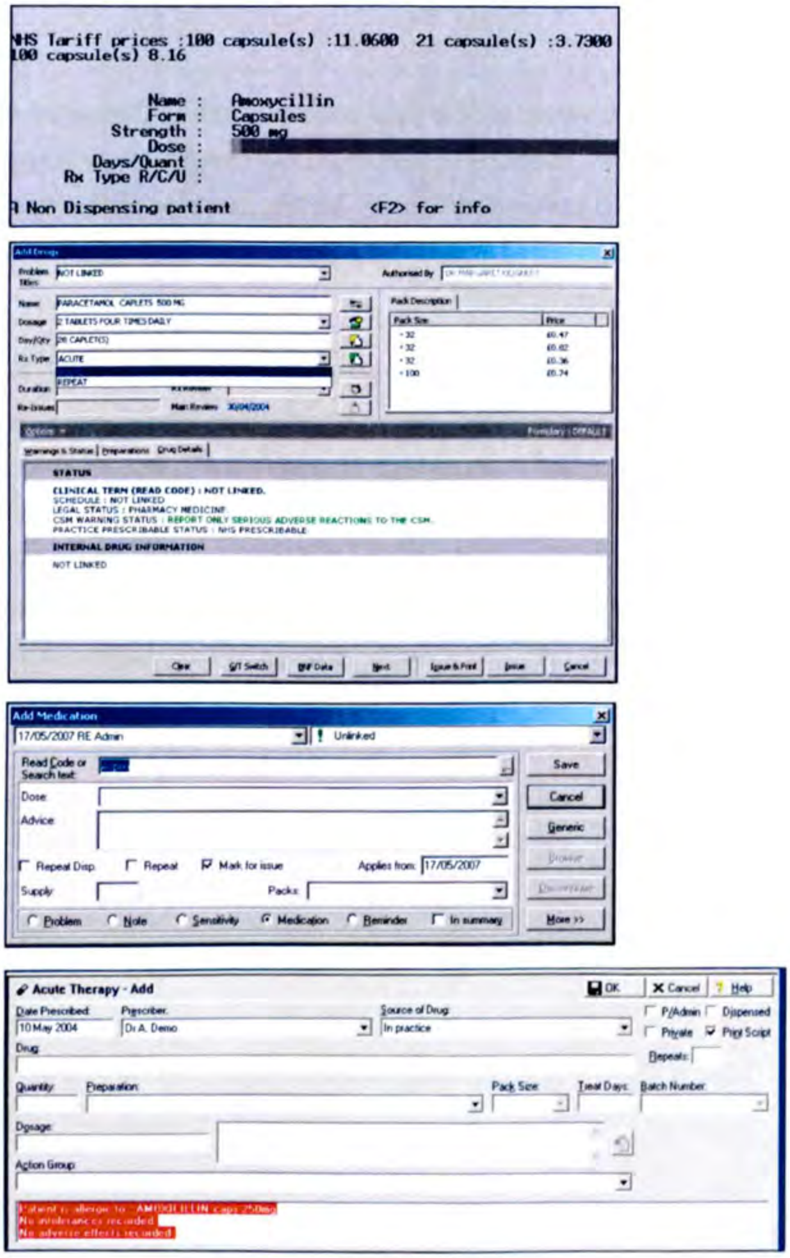


Figure 7.43: Interfaces used for creating new prescriptions in LV, PCS, Vision and Synergy (top to bottom).

7.5.1 Prescribing tasks – LV

Text link based initiation and limited navigation within the medication list

Doctors observed using the LV system, initiated the prescribing tasks using function keys associated with the main set of navigation text links. They first activated the '*medication*' option, which takes the user away from the main consultation interface and presents the '*prescriptions*' page. This new interface contains a list of current prescriptions detailing drug name, preparations and dosage together with the date issued for each item. Any side effects reported by the patient are also shown under the drug name in a differently coloured text. Repeat and acute prescriptions are shown in the same list, separated by appropriate headings. LV users did not perform any navigation related interactions in this page; they reviewed through the list making use of the single page view.

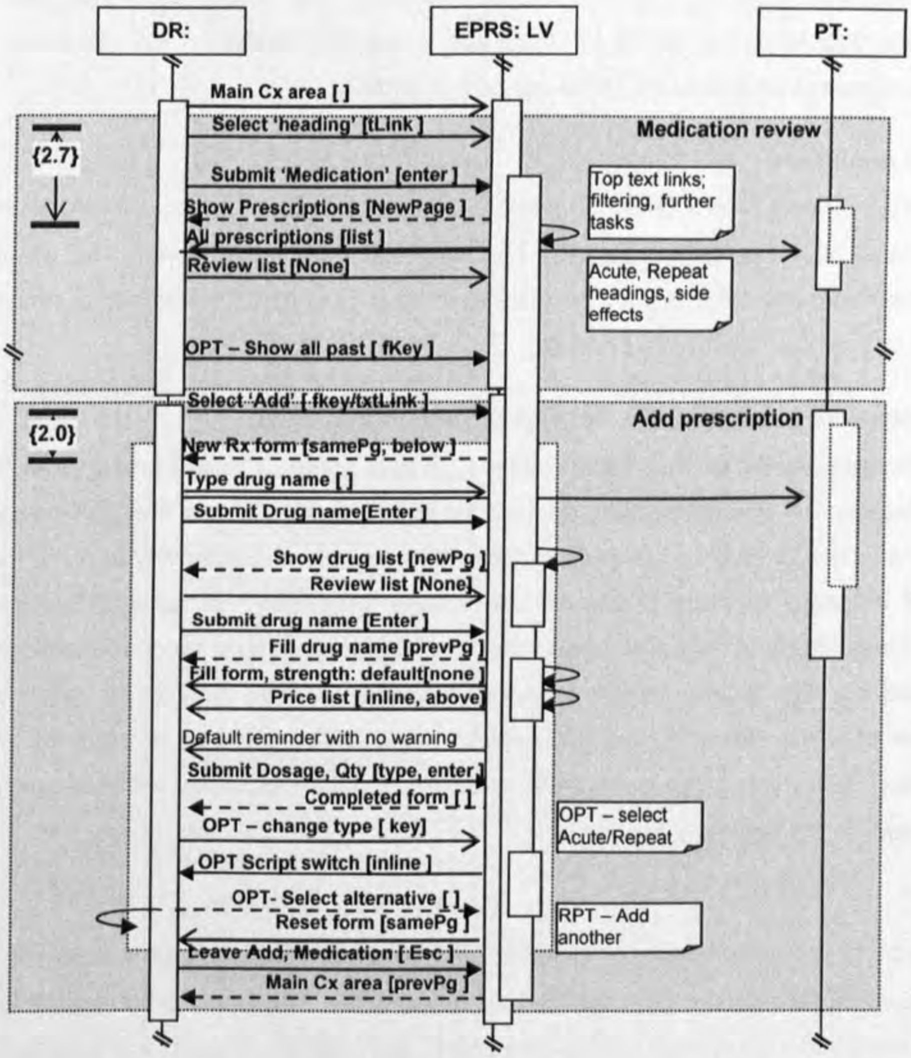


Figure 7.44: Process model of past prescriptions review and creation of a new acute prescription in LV

Even though the consultation summary view indicates the prescriptions created at each encounter, in 41 occasions (71.9%) LV users visited the *prescriptions* page to review the list of medications. Furthermore, in certain instances they went on to review all drugs patient was prescribed with in the past, by typing in a function key (character key *x*). The header section of the prescriptions page displays a set of text links representing various prescribing related tasks. There are 16 different links; each has an associated key board character that acts as a short-cut key to activate the particular task.

Vertically organised input fields with sequentially changing interaction focus

LV users initiated the new prescription creation process by selecting the '*add*' option from the list of text links. Data entry form for new prescriptions has a vertically arranged set of input fields; they accept the drug name, preparation, dosage and type of prescription sequentially. No other interactive elements are visible in the interface. The set of navigation links at the top gets replaced by a list of generic drugs patients is currently under.

Users have to first type in the drug name and press the '*enter*' key, which presents a list of different preparations for the requested drug. Selection of the desired drug, which most users did using navigation keys results in populating the details for '*form*' and '*strength*' of the drug. A single line of text over the main prescription data entry area indicates pricing details.

Embedded alerts and reminders

The top half of the screen shows drug interaction warnings if relevant. This reminder information and the drug details have no visual differentiation. This reminder information is removed when doctors selected the exact dosage information. LV users then have to supply the quantity of drugs in numeric format and specify the type of prescription.

Common workflow elements for both acute and repeat prescribing tasks

At initiation of the prescribing tasks, no separation between a new acute or repeat prescription is visible. After having entered the dosage details, doctors indicated whether to consider the newly added prescription as a repeat or as an acute prescription using a single character key (e.g. '*R*' for repeat). Then a brief message appears in the bottom stating '*processing scriptswitch*', which evaluates and inform if any alternative recommended drugs exist. If there are no recommendations to display, the prescribing interface is reset enabling the user to add details for another prescription. User can print the newly added prescription using a function key or store to be processed later. System then moves the focus back to the prescription list view, with the newly added prescription shown in the bottom of the list.

'Quick keys'

LV has a facility to store a pre-determined combination of Read code problems and medications and assign a short-cut key to them. There are referred as 'quick keys'. They need to be defined for adults and children separately, and stored against the user's login details. Though this approach provides an efficient and consistent way of recording details and prescribing medications with possible time savings, none of the LV users in the study sample used such techniques. Within the main consultation view, it is possible to activate the *quick keys* by pressing 'Q' which shows a list of stored Read terms, selecting an item presents the pre-recorded list of prescriptions. When a user selects a specific prescription, both the problem title and the medication details are added to the main consultation screen. This eliminates at least eight different interactions associated with prescribing data entry.

7.5.2 Prescribing tasks - PCS

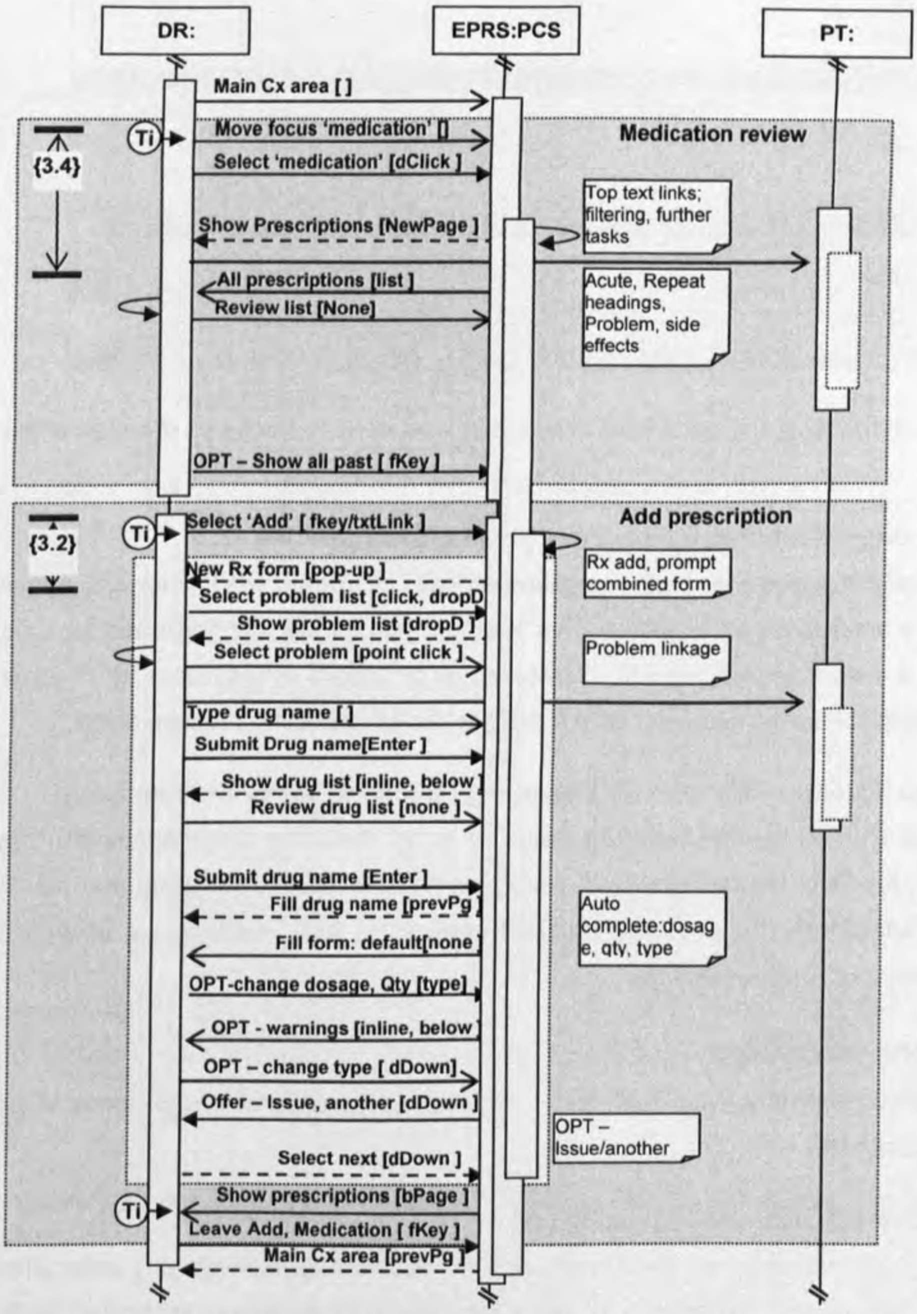


Figure 7.45: Process model of past prescriptions review and creation of a new acute prescription in PCS

Medications list with problem linkage and the numerous text links

PCS users either *double clicked* on the '*medication*' heading in the main consultation data entry area or pressed a function key (*F9*) to initiate the prescribing tasks. System then presented the *prescribing* page, initially showing the list of current prescriptions. This page has a top navigation area containing text links for 28 different functions. By clicking on a link or pressing the associated character key initiates a new task. The list view contains all drugs currently used by the patient, separated by headings for different prescription types; as acute and repeat. Each entry has the drug preparation and dosage information. The problem term associated with each prescription is also shown in a different colour.

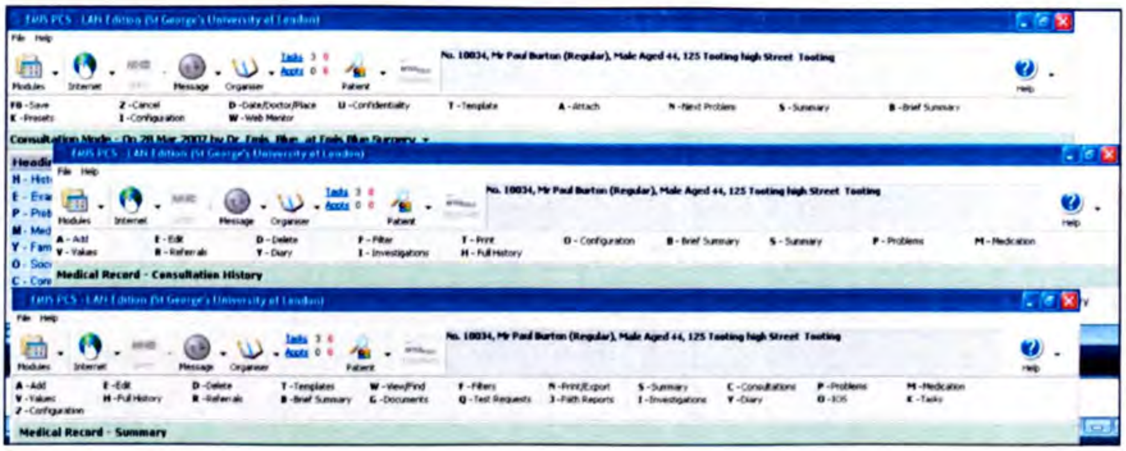


Figure 7.46: Changes in the type and order of available text links in PCS, based on the area of the record being visited.

Drug entry form as a pop-up window, medications list in the background

When PCS users initiated the new prescription creation process, a pop-up window for drug detail entry appears over the medication list interface. This interface has its top half dedicated for drug information entry and a lowers section used for displaying list of options or reminders. PCS users first performed a problem linkage by selecting from a drop down list of existing problem terms.

Dedicated area within the data entry form for displaying options to select and reminders

After PCS users have entered the desired drug name, a list of matching drugs appears in the bottom section of the interface. Doctors selected a drug from the presented list using the mouse pointer. This filled in the details for all remaining data entry fields with matching set of default values; dosage, quantity and prescription type.

Adding as a new repeat prescription

To place a newly added prescription into the *repeat* category, the appropriate type needs to be selected form a drop-down list.

Second pop-up window for prescription issuing tasks

After the prescription type was selected, the bottom part of the interface displays any associated alerts and reminders, and offered the options to issue, print or create another prescription. When users chose the '*issue*' option at this particular point, a second pop-up window appears requesting the issue method; print, store, private and so on. Specifying the issue method cleared the prescribing pop-up window and brings the focus back to the medication list view.

The newly added prescription then appeared in the list under the appropriate category. In situations where the prescription was not issued immediately after its creation, doctors highlighted the relevant scripts using the mouse pointer and printed multiple items together. If there were any under or over dosage issues, a final pop-up window appeared requesting to comment on the *drug supply information* before the print request operation was performed.

7.5.3 Prescribing tasks - Vision

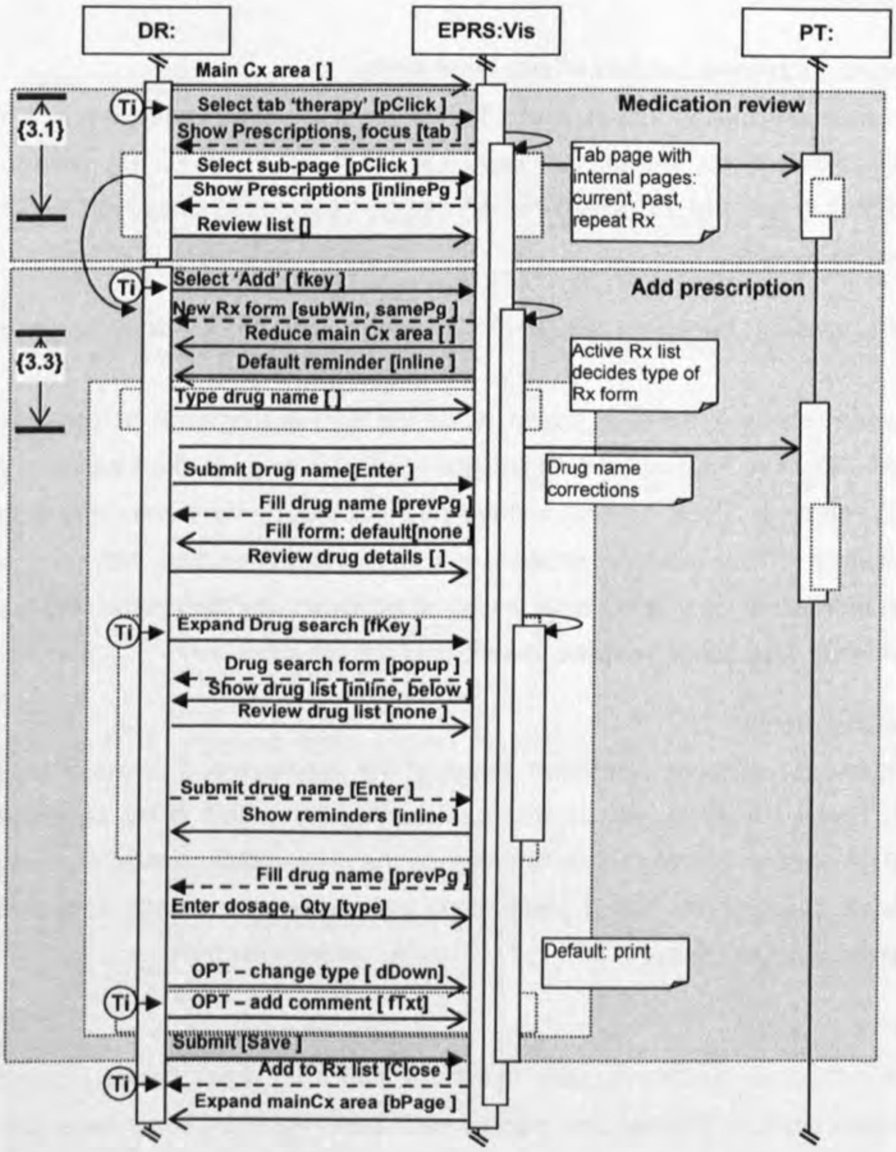


Figure 7.47: Process model of past prescriptions review and creation of a new acute prescription in Vision

Medication list view with separate pages

Vision users who wished to review through the medication lists first selected the '*therapy*' tab from the middle sub-window. The therapy page contains a prescription list, which has three separate pages; for current, past and repeat prescriptions. Vision users had to select between these three pages to review medication details. Each entry in the list indicates the issue date, drug name and dosage information under different columns; due to the limited display area used, the list view is compact. The number of columns in the list seemed to depend on the type of prescriptions being reviewed.

Sub-window based interface with separate designs for acute and repeat prescribing

Vision interface continues to maintain its four sub-window structure during the prescribing tasks. All Vision users who activated the process for creating a new prescription used a function key. Based on the type of prescription list active at the time, Vision presented data entry forms with different formats; form displayed when in the '*current*' medication view was different than the one displayed when in the '*repeat*' medication view.

Non-sequentially arranged, increased number of text input fields

The data entry form for acute prescribing has thirteen different text fields. One larger field in the bottom is allocated for displaying alerts, and another large text box in the middle has no label to indicate its purpose. The bottom text field, by default has a message highlighted in bright red colour stating '*no drug allergy status recorded*'.

Direct selection of the closest matching drug – a separate pop-up window for any alterations

Entering of a correct drug name selects the default preparation and fills the drug name and dosage fields in the data entry form. Doctors, who wanted to prescribe a different drug, used a function key to obtain a separate drug search interface. This second interface displayed a list of matching drug names and the lower section of the interface showed any additional information. Selecting a specific drug preparation took users back to the main interface, which was by then containing the newly entered drug information. Users then supplied quantity and dosage information.

Default selection of issuing status

There are four check boxes in the upper right hand corner of the interface, one of which is to specify whether the new script should be printed; this was selected by default in the observed consultations. When a user pressed the 'ok' button to complete the prescription creation process, newly entered details were added to the list of medications and a pop-up message appeared indicating that the new prescription is printing.

'Prescription manager'

Unissued prescriptions are shown in a different colour in the medication list views. For issuing and printing prescriptions, Vision users highlighted and marked each item. Unissued items were then moved to another list identified as 'prescription manager', using which the doctors printed any unissued prescriptions.

Interface for creating new repeat prescriptions

The repeat prescribing interface in Vision is essentially the same as the one used for acute prescribing, except for the existence of two additional text boxes; an input field to indicate the batch number associated with the repeat prescription and another to specify the end date. When users pressed the 'OK' button on this interface, the prescription detail appeared in the repeat prescriptions list.

7.5.4 Prescribing tasks - Synergy

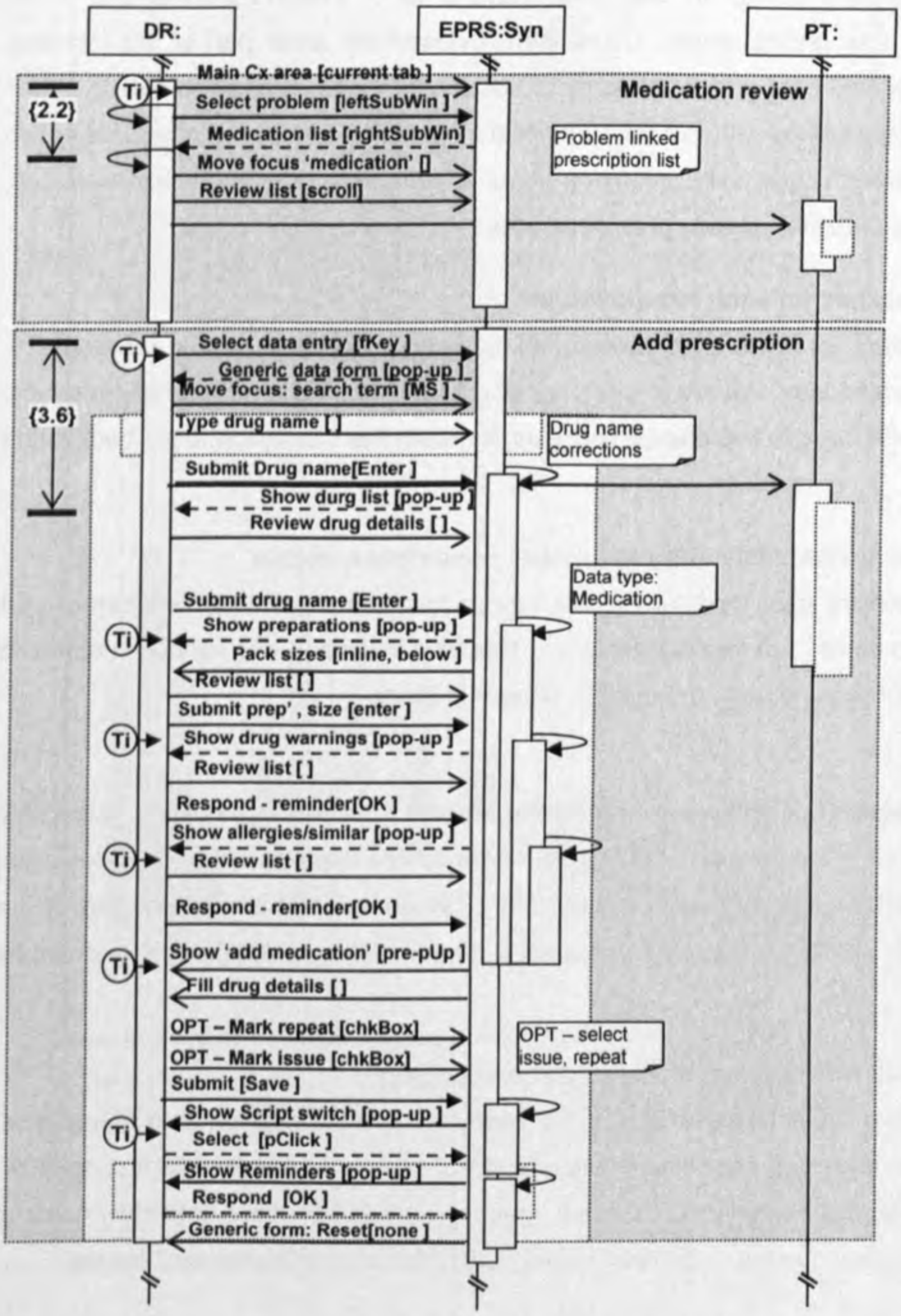


Figure 7.48: Process model of past prescriptions review and creation of a new acute prescription in Synergy

Generic data entry form based, direct prescribing without medications list view

Synergy users use the generic data entry form, also to perform prescribing tasks. When a user entered a drug name into the usual read term search input field, the data entry form recognised it as an intention for prescribing. Accordingly, Vision users in the study sample did not perform any specific interactions with a medication list or explicit navigations to initiate a prescribing process.

Additional pop-up windows for specifying prescription details

When the generic data entry form detects the doctor's intention to add a new prescription, it responds by providing a second pop-up window with matching drug names. Users then have the option to select the desired drug name or to refine the search. Selection of a particular drug moves the users' attention to a third pop-up window which have a list of different preparations of the selected drug, together with pricing details. Users then reviewed the lower part of this interface which presented a list of different pack or unit sizes to specify the exact preparation details. When doctors completed the interactions with this third *formulation selection* window, another one or two pop-up messages appeared sequentially, informing about any possible drug interaction warnings, allergies or similar drugs patient is already prescribed with.

Individual pop-up messages for each reminder type

Synergy interface structure for prescribing is designed to present individual pop-up messages to each alert or reminder categories, instead of grouping all relevant information to a single interface. Users had to interact with three to five pop-up windows, to return the interaction focus back to the initial data entry form.

Altered interface of the generic data entry to accepts prescription details

When the generic data entry form received the input focus for the second time, its interface had been altered to function as an '*add medication*' form. This form was filled with various information user specified previously going through the number of pop-up alerts.

Problem linkage

Following the same problem orientation principal that is central to the Synergy's design, each new prescription is also linked to a particular problem title, which can be altered using a drop-down list. The series of radio buttons with five different data entry categories, that is inherent part of the generic data entry form persists in the *add medication* form; with the type 'medication' selected by default.

Reforming the interface with extensions for repeat prescribing

Users interacted with two check-boxes to specify the newly created prescription as a repeat type, and also to mark it for issuing. If the *repeat* option is selected, the data entry interface gets re-drawn with an additional lower extension. This new interface section has three data entry fields to supply the information about number of repeats, expiry data and the duration between issues.

Pop-up messages during saving– repeated display of reminders

Saving the new prescription details resulted in further two sets of pop-up alerts; one recommending alternative cheaper drugs if relevant (*scriptswitch*) and a second group of messages reminding again about the drug interaction warnings. In effect, some of the messages that appeared at this stage had already been acknowledged by the doctor in previous steps. *Saving* the prescription resets the data entry form back to the generic form. *Closing* the form brings the main consultation interface to the foreground. Newly added prescriptions were shown in the summary view associated with the particular problem title.

Pop-up window for issuing

Synergy users initiated the prescription issuing process by pressing a function key (*F9*). This brought up a pop-up window with a list of all prescriptions available for issuing. Doctors pressed the 'enter' key to accept the default option for printing all unissued prescriptions.

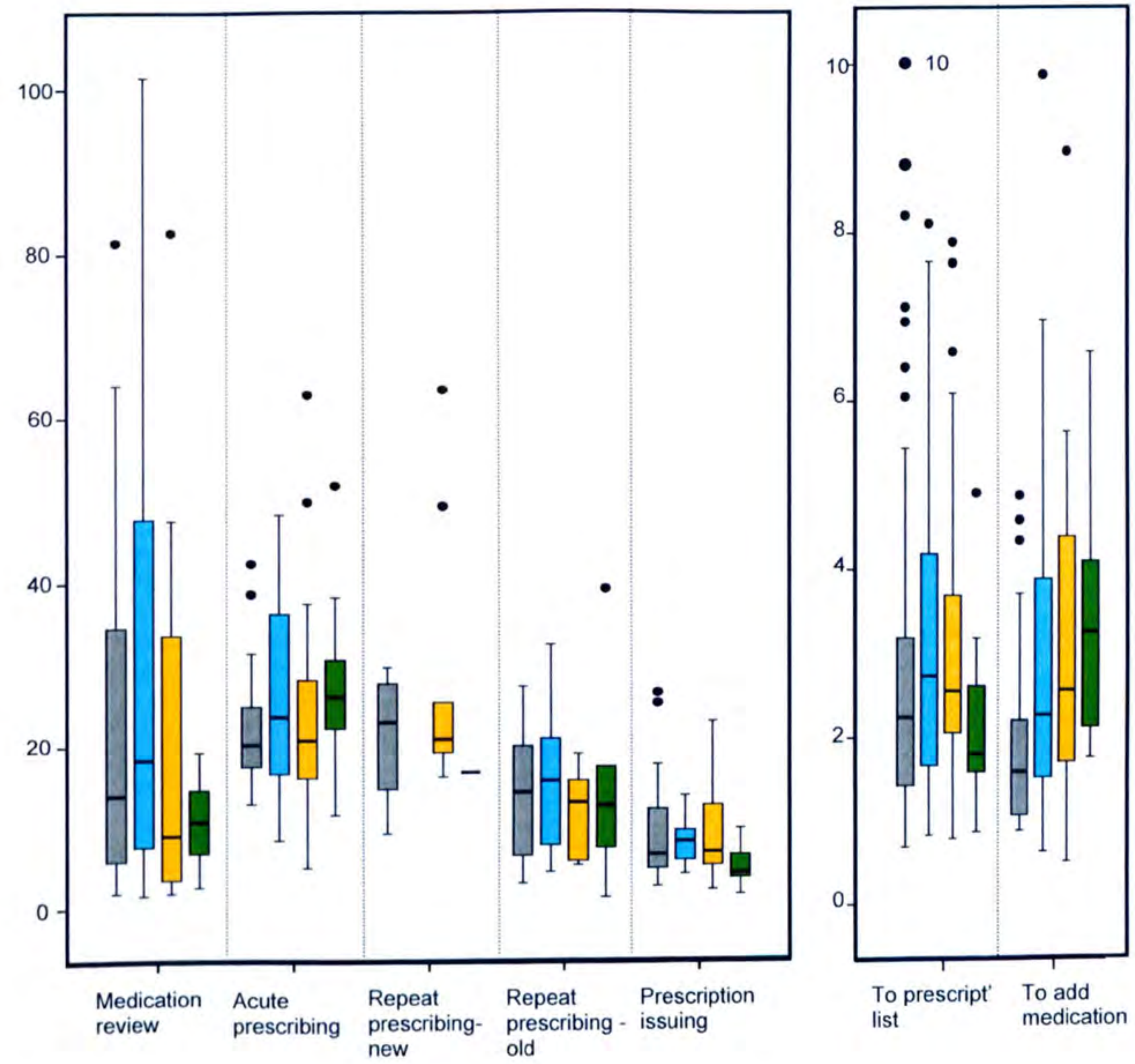


Figure 7.49: Box plots representing the time spent on prescribing tasks and for their initiations. (EPR systems are in the order of LV, PCS, Vision and Synergy)

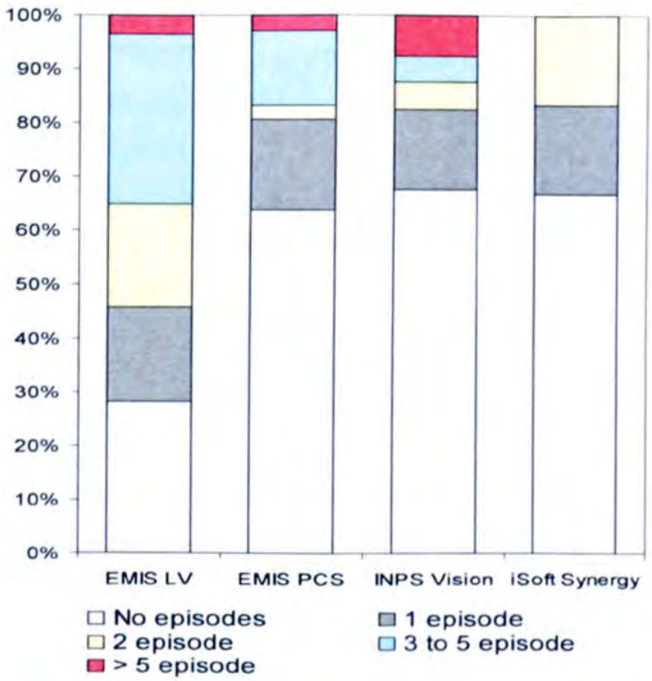


Figure 7.50: Proportions of the consultations with past prescription reviewing tasks, by system

	Consult-ations N	Number of past prescriptions reviewing episode during a consultation									
		None		1 episode		2 episode		3 to 5 episode		> 5 episode	
		N	N%	N	N%	N	N%	N	N%	N	N%
LV	57	16	28.1	10	17.5	11	19.3	18	31.6	2	3.5
PCS	36	23	63.9	6	16.7	1	2.8	5	13.9	1	2.8
Vision	40	27	67.5	6	15.0	2	5.0	2	5.0	3	7.5
Synergy	30	20	66.7	5	16.7	5	16.7	0	0.0	0	0.0

Table 7.8: Number of past prescriptions reviewing episodes, by EPR system

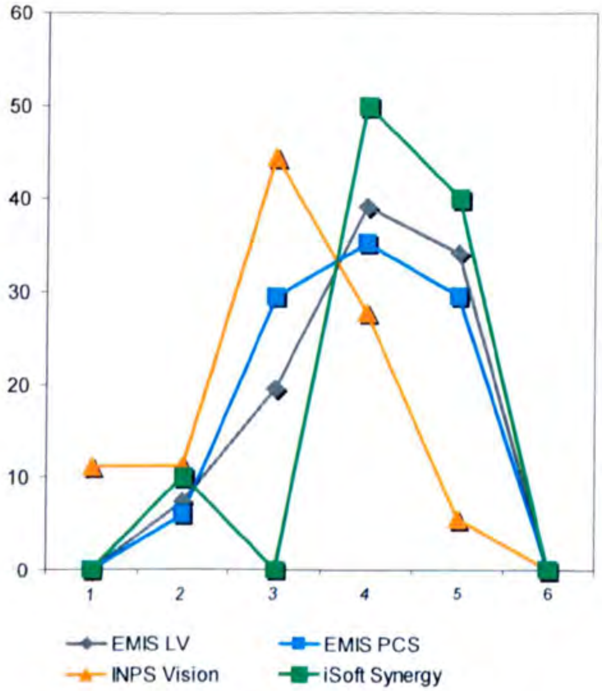


Figure 7.51: Distribution of past prescription reviewing tasks across the consultation length.

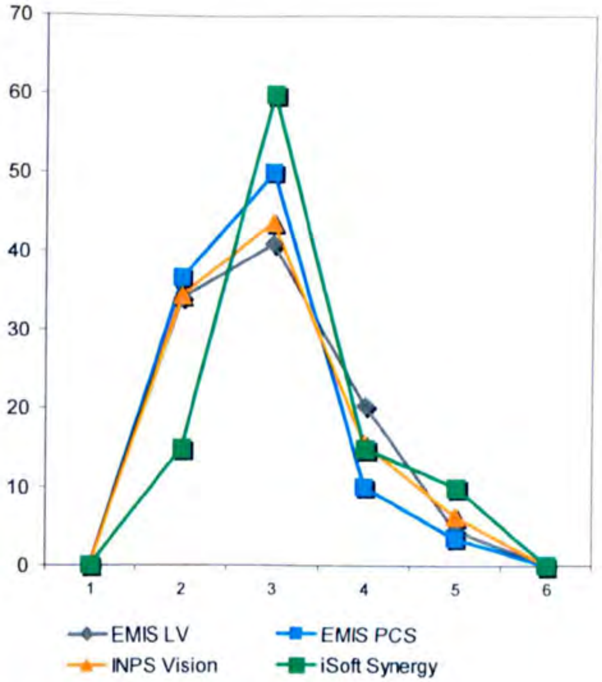


Figure 7.52: Distribution of acute prescribing tasks across the consultation length.

Distribution of past prescription reviewing task							
	Episodes N	**Initial-marginal (N%)**	**Core Q1 (N%)**	**Core Q2 (N%)**	**Core Q3 (N%)**	**Core Q4 (N%)**	**Final-marginal (N%)**
LV	41	0.0	7.3	19.5	39.0	34.1	0
PCS	17	0.0	5.9	29.4	35.3	29.4	0
Vision	18	11.1	11.1	44.4	27.8	5.6	0
Synergy	10	0.0	10.0	0.0	50.0	40.0	0

Table 7.9: Distribution of prescription reviewing tasks across the consultation length, by EPR system

7.5.5 Number of prescription reviewing episodes

Except in consultations conducted with LV system, majority of the consultations with other EPR systems have few interactions aimed specifically at reviewing prescription lists. Proportions of consultations with no prescription reviewing are 63.9% to 67.5% in PCS, Vision and Synergy respectively, compared to 28.1% in LV consultations. Function key based navigation enabled LV users to reach the prescription list easily, with minimum need for hand-eye coordination. This reduced the time needed to initiate compared to the use of mouse pointer to interact with the text links.

Proportions of the consultations with a single occurrence of prescription list reviewing interactions are similar between the systems, ranging only from 15.0% to 17.5%. Multiple occurrence of the same interaction is associated with the new prescription creation tasks, however the interface design appeared to influence in situations where they occurred more than three times. If visible in the back-ground or in a side view when the main data entry interactions are taking place or interacting with the patients, doctors referred to the prescription list without additional efforts. Aforementioned behaviour was observed amongst Synergy users, they had the list of medications linked with the problem being discussed in their right-hand side window; they did additional interactions to explore medication list only in 16.7% of consultations. In contrast, remaining three EPR systems have consultations where more than three prescription reviewing interactions have occurred; minimum of 12.5 in Vision and maximum of 35.1 in LV.

7.5.6 Time allocated for reviewing past prescription lists

While Synergy users had to review the medication list less regularly, they also allocated the shortest durations for such tasks (mean=10.8s, SD=5.3s). Problem oriented medication list in Synergy is a part of the main consultation view; doctors mostly interacted with it to move through the list instead of more demanding filtering or grouping tasks. Synergy users also had the shortest range of durations for medication reviewing (IQR=8s,min=3s,max=19s, all other systems have IQR>18s).

Users of both LV and PCS, who were interacting with interfaces with large amount of test links to explore the medication list spend durations that are more than twice compared to Synergy users (LV; mean=28.6s, SD=29.5s, PCS; mean=34.7s, SD=34.3s). PCS, which is having a GUI interface out of the two, is associated with both the largest duration and the range (IQR=51s, min=2s, max=1:50mins).

7.5.7 Initiation of medication review interactions

Interface and workflow designs seem to be making a significance difference between the systems when time taken to initiate medication review tasks is concerned (p=0.018). Synergy's problem oriented medication list view has the shortest initiation time (2.2s, SD=1.1), while PCS's text link and function driven approach takes the longest (mean=3.4s, SD=2.1s). Despite having text links, LV users who mostly interacted using function keys have a relatively faster initiation time (mean=2.7s, SD=1.8s). Initiation time in Synergy is significantly faster than both PCS and Vision (p=0.012 and p=0.048 respectively).

7.5.8 Time taken to create a new acute prescription

The numerous pop-up windows doctors confronted when using Synergy, resulted in lengthening time needed to create a new acute prescription (mean=26.8s, SD=9.3s). The keyboard based navigation and sequential movement between vertically arranged input fields enabled LV users to generate a new prescription in the shortest time (mean=21.6s, SD=6.2s). Doctors using LV also have a shorter range of durations (IQR=18s, min=7s, max=1:06mins), the amount of unexpected feedbacks doctors received from the LV interface was minimum. Two outliers in LV represent situations where repeated searches for drug names were done. PCS users spent longer durations interacting with the list of drug preparation, and often reviewed the information presented in the lower section of the interface. They have the second longest durations for acute prescribing (mean=25.4s, SD=11.8s), situations where doctors decided to review the pricing details are responsible for most of the longer duration data entries.

7.5.9 Time taken to initiate acute prescribing interface

The time LV users spent activating the prescription data entry interface is significantly shorter compared to the remaining three systems (p=0.001). By interacting using the function keys, LV users managed to reach the prescribing interface in two seconds (SD=1.1s). The next fastest reported from PCS consultation is 3.2 seconds long (SD=2.3s)., while Vision is associated with a slightly higher initiation duration (mean=3.3s, SD=1.9s). Users of both those systems interacted with text links or graphical icons using the mouse pointer. The strategy used for prescribing initiation, by automatically recognising drug names doctors enter into the generic data entry form has in fact resulted in longer durations (mean=3.6s, SD=1.6). Most Synergy users appeared as taking extra care when typing in a drug name, often doing corrections before submitting it. This was probably influenced by their intentions to provide a drug name as accurate as possible, to assist Synergy's drug name recognition technique.

7.5.10 Repeat prescribing – old and new

Except in Vision, in all other systems indicating a newly created prescription as belonging to the repeat category can be done using a single interaction. None of the PCS users took part in the study created new repeat prescription, and only one instance was recorded amongst the Synergy users. Vision users, who interacted with an interface dedicated for repeat prescribing, in fact spent about six seconds longer to generate a repeat prescription compared to a LV user (LV; mean=21.1s, SD=8.9s, Vision; mean=27.5s,SD=15.7s). LV users categorised a new prescription as repeat only by typing character 'R'.

Re-authorising an existing repeat prescription does not involve more than three interactions in any of the systems. The duration doctors spent are similar between the different systems; mean durations range from 11.4 seconds to 16.2 seconds (p=0.722).

7.5.11 Issuing prescriptions

Amongst the various interaction approaches adopted by EPR systems for issuing of created prescriptions, the pop-up window based approach appeared to be the easiest for doctors to interact with. Doctors had to give more attention to character key or mouse based selection of items in the un-issued prescription list, initiation of this particular section of the interface also required multiple interactions. Such situations were particularly observed amongst the LV, PCS and Vision users; their associated mean durations for prescription issuing are more than eight seconds (mean ranging from 8.1s to 9.3s). In contrast, Synergy users activated the prescription issuing interface using a function key and pressed the 'enter' key accepting the default selection. They spent only five seconds for issuing a set of prescriptions (SD=2.3s).

7.5.12 Verbal and non-verbal interactions

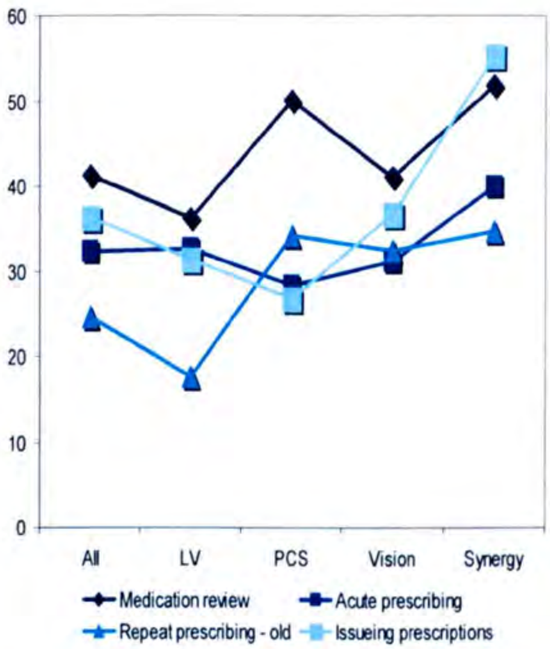


Figure 7.53: Proportion of prescribing tasks with verbal interactions, by EPR system

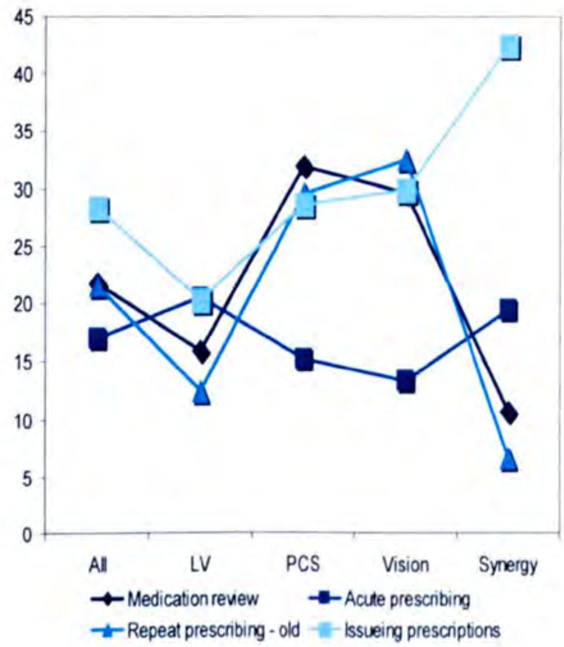


Figure 7.54: Proportion of prescribing tasks with eye contact, by EPR system

During the medication reviewing episodes, doctors verbally interacted with patients for about 40% (SD=28.7%) of the duration. In most occasions doctors commented about the existing medications, and were expecting the patients to respond confirming or to raise any issues. During a consultation with Vision, and in another with LV, patients mentioned about side effects of past medications. Doctors responded to this by exploring the full list of past prescriptions. Lack of problem linkage resulted in doctors spending a prolonged time to locate the medication in both occasions. In three separate instances, doctors added comments to existing prescriptions in response to patient comments.

Problem titles displayed in PCS and problem linkage approach in Synergy, were utilised by doctors to make comments. More than half of the medication reviewing durations with both systems overlapped with verbal interactions (PCS; mean=50.1%SD=47.6%, Synergy; mean=51.8%SD=27.5%).

		Computer use task											
		Medication review			Acute prescribing			Repeat prescribing -old			Prescription issuing		
		Cx N%	Mean (t%)	SD (t%)	Cx N%	Mean (t%)	SD (t%)	Cx N%	Mean (t%)	SD (t%)	Cx N%	Mean (t%)	SD (t%)
All	**Verbal**	88.3	41.3	28.7	92.2	32.3	17.4	88.2	24.5	19.6	76.5	36.2	27.3
	Eye	64.9	21.7	19.3	77.8	17.0	15.2	50.0	21.5	23.4	55.9	28.3	25.0
LV	**Verbal**	90.2	36.2	20.1	90.6	32.6	17.9	94.4	17.6	14.1	95.0	31.3	22.4
	Eye	68.3	15.8	11.4	75.0	20.5	18.0	33.3	12.4	14.3	65.0	20.3	15.9
PCS	**Verbal**	92.3	50.1	47.6	90.9	28.4	14.7	100.0	34.1	29.9	75.0	26.8	27.7
	Eye	92.3	31.9	27.8	77.3	15.2	13.5	100.0	29.5	23.6	50.0	28.6	24.3
Vision	**Verbal**	84.6	41.2	27.5	95.7	31.2	17.9	71.4	32.4	21.5	75.0	36.6	26.3
	Eye	61.5	29.6	21.5	87.0	13.3	13.6	57.1	32.6	35.2	65.0	29.8	26.6
Synergy	**Verbal**	80.0	27.5	40.0	92.3	19.2	34.6	75.0	18.0	55.3	56.3	32.8	27.5
	Eye	20.0	10.6	4.0	69.2	19.4	12.8	50.0	6.6	5.6	37.5	42.5	36.4

Table 7.10 Verbal interactions and eye-contact during prescribing tasks, by EPR system

LV users in general verbally and non-verbally interacted less during all prescribing tasks. In contrast, Synergy users were observed verbally interacting more compared to users from other systems. Prescription issuing in Synergy is the least demanding, due to the use of function keys and default options; both verbal interactions and eye contact between doctors and patients were largely unaffected by prescription issuing interactions.

Acute prescribing workflow had less association with the doctor-patient interactions. Even though PCS users spent more time creating acute prescriptions compared to LV users, doctor-patient interaction has the opposite relationship; PCS users interacted about 4% less with their patients. Regardless of the type of interface user, Vision users verbally interacted similarly during acute and repeat prescription creation (31.2% and 32.4%). However, they made less attempts to make eye contact when creating a new acute prescription; 13.3% compared to 32.6% when repeat prescribing.

7.6 Summary

There are common consultation tasks visible in the computer mediated consultation. Their (1) presence, (2) distribution within the consultation time line, (3) duration and (4) process structure vary. The influences these characteristics have on the doctor-patient interactions are observable. This results in positively acknowledging the research hypothesis Hs6. When certain common consultation tasks are compared across different EPR systems, significant differences of doctor-computer interactions exist. These differences are attributable to the electronic patient record system design features. These findings accept the hypotheses Hs7. Furthermore, the hypothesis Hs8 has also been accepted. The process models of the consultation tasks provide analysable insights into task structures and facilitate delineating of characteristics linked to the information system design features. Acceptance of these three research hypotheses linking the EPR features to process characteristics implies the potential to manipulate the design of the information systems to direct this impact positively, to facilitate the consultation to be more patient centred.

The capacity of process modelling approaches to provide insight into the consultation tasks has been proven by the process models described in this chapter. This recognises the validity of the research hypothesis Hs8. There are a number of observations, which have been validated through process models and could potentially be useful when designing clinical systems. Reviewing of past encounters is common. Doctors tend to use past medical history details intermittently if available in default view of the EPR system. Keyboard driven navigation functions allow information reviewing tasks to be completed rapidly, with more eye contact with patient. Screen sharing occurs mostly with test results and medication reviewing interactions.

There are many unnecessary steps when recording data as part of common consultation tasks. If these were removed those tasks might be completed faster. Clinical coding is faster when auto suggestion techniques are in place. There are advantages if this could be done in a 'context aware' manner, where terms are suggested based on previous recordings, current problem title, active problems, and the consultation heading being used. More coded items are recorded when problem oriented free text entering strategies are used by the system design, however codes entered are less specific. Difficult picking list interactions take longer; doctors prefer re-wording of search instead of browsing through a long list. Coded-free text transition is faster in embedded approach, where both types of data entry can be done alternatively.

The availability of contextual data positively influenced the doctor-patient interactions when using blood pressure recording interfaces, whilst the manner of activation and their interface structures determining doctor-computer interaction time. Time taken to navigate into, and the movement of the input focus within the interface determines the blood pressure data entry time. Prescribing tasks are often initiated after reviewing past medications. Prescribing functions varied greatly, most notably in the numbers of prompts given when adding a new medication and the influence of system suggested values when completing the prescription details.

The time doctors spend on navigating between different areas of the EPR content and the prompts triggered by the computer often resulted in introducing unexpected doctor-computer interaction durations.

Doctors tend to acknowledge and respond to prompts presented by the EPR system while ideas are not framed, whereas prompts encountered late in decision making are mainly instantly cancelled. Supplementary information prompt doctors to make task related comments and have the potential to support patient-oriented interactions in parallel to the computer use.

CHAPTER 8

Discussion and conclusions

8.1 Introduction

This chapter discusses the findings of this study. A theoretical framework based on the triadic' relationship apparent in the computer assisted general practice consultation is first presented. It aims to promote the role of the EPR system, based on the 'goal-responsibility-action' model introduced previously. This is followed by a number of discussions based on the 'context, time and process' elements of the consultation, and principal findings associated with each. The position of the each research hypothesis is also considered. A number of analytical elements utilised for this study are then synthesised into a classification framework with eight elements. This is followed by a set of recommendations for clinical system design. Finally, the findings of this study are compared to the existing literature, limitations and future work are discussed, and are followed by the conclusions.

8.2 The EPR system as an *actor*

This research rationalises the prospect of considering the EPR system as an actor, when studying the consultation and designing information solutions. The influence computer has on defining consultation agenda, directing the workflow, enhancing or interfering with the doctor-patient interaction warrant such standpoint. The usual practice in Software Engineering is, for the purpose of capturing requirement capturing, the entity which plays the central role pertaining to the particular interaction model is designated as the system. In fact, the Use Case approach defines the system boundary demarcating the 'internal actor'. Entities that sit outside then interact with the system as 'external actors'. An internal actor could consist of multiple sub systems designed to deal with interaction requests of different sort, received from its external actor.

8.2.1 Goals, responsibilities and actions as the basis for interpreting consultation interactions

When the EPR system is observed as another actor, it is possible to articulate the Use Case model to indicate all three actors, doctor-patient and computer as having responsibilities and goals. An external actor can initiate a task to achieve a goal (e.g. click on an icon to initiate BP recording), thus becoming a primary actor. The EPR system which is at the receiving end of this interaction as the secondary actor then performs a suitable response (e.g. present the BP recording interface, validates the values). As part of a another Use Case, the EPR system may need the assistance of an external actor to fulfil one of its goals, making the external entity to become a secondary actor (e.g. requesting the doctor to select an alternative cheaper drug). These EPR system initiated interactions, together with the potential influence they could have on doctor-patient interactions and the direction of the consultation warrants the representation of EPR is an actor, The '*responsibilities, goals and actions*' based interpretation of interactions, may potentially place the computer in a position that is closer to the psychosocial aspects of the consultation. In the doctor, patient and computer triad, each has associated goals, and underlying responsibilities influenced by the role they play when performing a common consultation task. The nature of the assistance an actor may require or the influence it could have on another actor is useful when understanding the relationship between actors and the interactions they participate in. From a functional level viewpoint, each consultation task requires an actor to set one or more goals. Achieving some of these goals may require additional assistance from another actor. Recognising individual actor's goals and actions involved, reveal interactions essentially as a method of communication between actors. Those communications are initiated by one actor and received and acted on by another. A system designer who examines consultation interactions together with their underlying goal-action combinations is potentially better placed to propose less demanding information solutions.

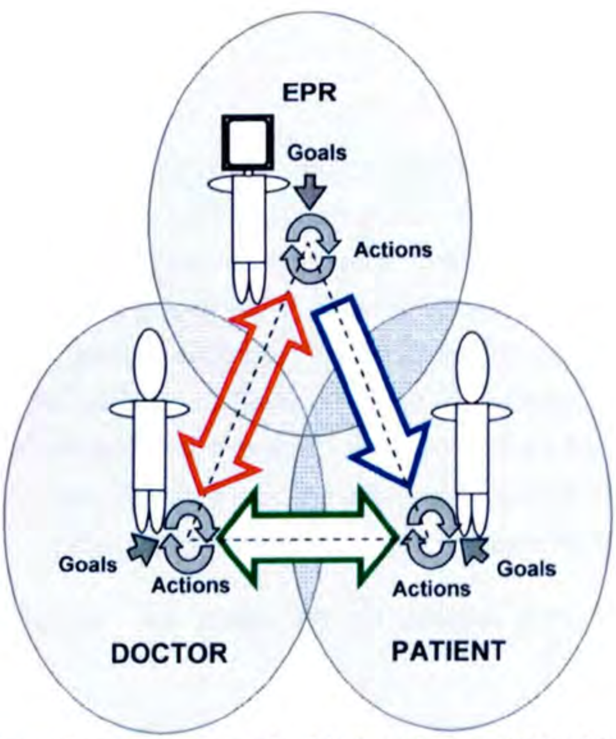


Figure 8.1: Doctor-patient-computer actor triad, and interactions driven by their objectives

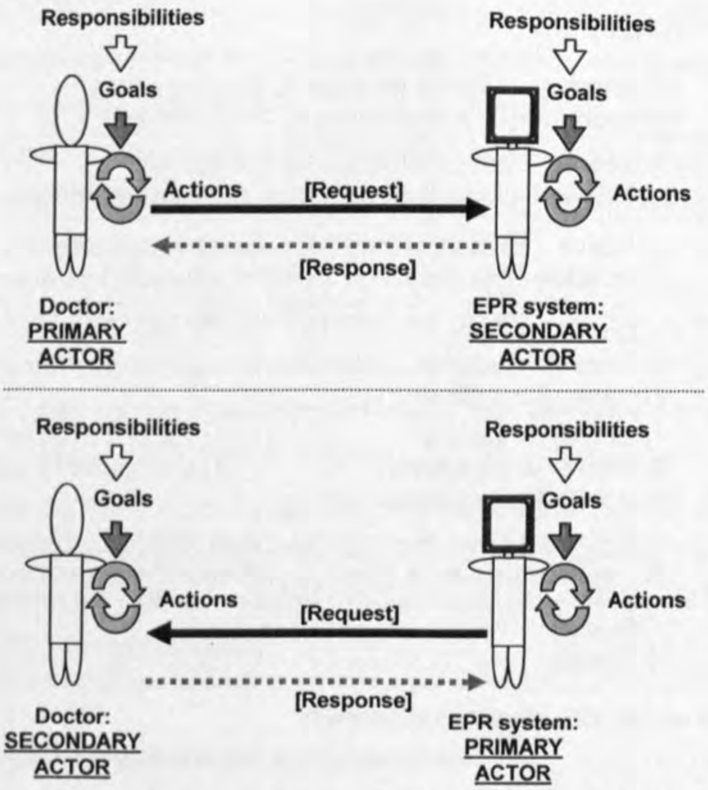


Figure 8.2: Doctor-computer interactions, and change of their roles from primary to secondary actors.

8.2.2 Descriptors for actors and interactions

A consultation represents various types of relationships amongst the actor triad. Based on who collaborates, the role they play and the numbers involved there are several descriptors linked with each common consultation task.

Doctor, patient or computer can act as the *primary* or become the *secondary* actor when performing common consultation tasks, nevertheless in a disproportionate manner. While some elements of this inequality are innate to the task type, there is another unanticipated component which is partly caused by the system design characteristics. For example, a doctor may allocate a specific duration to enter a coded item, however may find it demanding due to an extended picking list. Contextual aspects also have an influence. As with the consultation as a whole, individual consultation tasks also have initiators. Determined mostly by the task nature, either of the actors from the doctor, patient, computer triad could also function as *passive* or *active* actors. For example, blood pressure recording could be initiated as a result of doctor's motive, patient's request or prompt by the EPR system. Table 8.1 represents a classification of actor descriptors that is useful for detailing each interaction.

Activity/element	Descriptors	
1. Actor status	(1) **Primary** – initiated the consultation interaction (2) **Secondary** – was acted on by the interaction	
2. Actor position	(1) **Internal** – EPR system and its sub-systems (2) **External** – Doctor, patient and other external entities	
3. Actor role	(1) **Active** – capable of initiating a specific interaction (2) **Passive** – not capable of initiating a specific interaction	
4. Interaction path	(1) **Doctor-patient** (2) **Doctor-computer** (3) **Computer-patient**	
5. Interaction direction	(1) **Doctor to patient** (3) **Doctor to computer** (5) **Computer to patient**	(2) **Patient to doctor** (4) **Computer to doctor**
6. Interaction pattern	(1) **Synchronous** – message sender anticipates a response in reply (2) **Asynchronous** – conveys a message without waiting for a reply	
7. Number of actors	(1) **Dyadic** (2) **Triadic**	

Table 8.1: Involvement of actors and interaction descriptors

8.3 Context-time-process framework for consultation analysis

This research establishes the need to study the computer supported consultation from three standpoints; context, time and process. Those three elements are instrumental in exploring and meaningfully interpreting the complex relationships amongst the key roles involved and the influence of the setting. It is important to comprehend the context within which consultation is conducted, considering its un-predictable facets and the influential nature. This study ascertains the consultation room layout, method of calling the patient in, interruptions, consultation initiation and presence of persons accompanying the patient as having influence on the consultation's conduct. Time is a dominant element to recognise when studying a consultation, due to the constraints it can introduce to the amount or quality of interactions between doctor, patient and computer. The process element of this framework signifies the importance of detailing the consultation workflow along with the underlying tasks. It represents the importance of describing the complex social interactions involved, appreciating the intricate nature of practicing medicine, and intrusive or supportive characteristics of computer use.

8.4 Computer use characteristics and parts of the consultation

A doctor that interacts with patients and engages with the EPR system throughout the consultation appears to miss less prompts and create better medical records. EPR systems vary in the way they prompt doctors to record data and how they demand doctor's attention away from patient. Forcing doctors to record data could negatively influence the usefulness of the data entered, or doctors could find work around ways to record only what they believe as useful.

Computer use within a consultation varies depending on whether it is taking place (1) before inviting the patient in (initial marginal consultation), (2) while patient is in the consultation room (core consultation) or (3) after patient has left (final marginal consultation). Interpreting the computer use relative to those three time periods assist the recognition of design characteristics that are fit for purpose. Furthermore, across the consultation based on their occurrence three common consultation task types exist; (1) singleton tasks – occurs only once, (2) episodic tasks – can occur several times intermittently and (3) continuous – happens throughout the consultation in an unpredictable manner.

Regardless of the heterogeneity of computer use, doctors allocate a consistent proportion of the consultation to perform common consultation tasks using their EPR systems. At individual tasks level, the time doctor allocate, the amount of interactions needed and the associated doctor-patient interactions are influenced by the EPR system design. It is effective to compare the influence of computer on the consultation by categorising the computer use tasks into three types; as tasks for (1) reviewing information, (2) recording data and (3) taking actions. The amount of time doctors allocate to perform the first two categories of common consultation tasks seem to be particularly influenced by the EPR system design.

8.5 Styles of doctor-computer-patient interactions

A combination of categories is useful when describing consultation interactions; there are five different aspects. Findings of this study highlight the usefulness of the number of interaction styles discussed in chapter two and three, when describing these five interaction aspects.

(1) Doctor's use of computer - (a) minimal user; interacting with the computer after completing the main consultation tasks, (b) block user; intervals of alternating computer use and patient focused episodes or (c) conversational user; intermittently engaging with the computer.

(2) Doctor's engagement with patient - (a) responsive pattern of engagement, (b) acting as an information manager or (c) disengaging to take control of the consultation.

(3) Doctor's physical orientation during interactions - (a) unipolar – body oriented towards computer and moving only the head towards patient to interact or (b) bipolar – body orientation is alternating towards computer and patient.

(4) Patient's involvement in the consultation - (a) dyadic style, where interactions are mainly focusing on either the doctor or computer screen or (b) triadic – sharing the focus between computer screen and doctor.

(5) Role played by the computer - (a) an informant - supplying useful information, (b) a prompter – acting as an aide memoire or (c) a distracter that demands doctor attention away from the patient.

8.6 Consenting process

Patients accept multi-channel video recording as an acceptable approach for observing clinical consultations. When patient consent is sought on the day of recording, involvement of both practice staff and researchers to introduce the study contribute to increase patient confidence, awareness about the study and result in low refusal rates. Practice staff is best placed to explain the consultation observation to patients and introduce the researchers involved. This can be followed by researchers giving a detailed overview of the study objectives, process involved and opportunity to ask questions. Two step consenting; getting patients' approval before and after the recording is also useful to increase patient confidence.

8.7 Principal findings – context of the consultation

The results related to the contextual factors signify a range of elements, as having an influence on the general practice consultation. These findings contribute to the acceptance of the third sub hypotheses; '*There are contextual elements that can be influential in defining the duration and nature of computer use*'.

8.7.1 Patient calling-in method

The approach doctors adopt to invite patients in has an influence on the consultation initiation. Physically meeting and collecting the patient is the slowest. It results in creating a distance between initial encounter reviewing tasks and start of the core consultation where main doctor-patient-computer interactions take place, however those gaps are fairly consistent. Remote calling-in methods are faster, with over-the phone announcing approach taking less time than the screen display based method.

Doctors using remote calling-in methods spend a fairly consistent proportion of time interacting with the computer before inviting the patient and engage in opportunistic computer use until the patent's arrival. Regardless of the method of calling-in use, doctors always wait for patient to sit, before initiating the interactions aimed at discovering the reason for attendance.

8.7.2 Room layout

The inclusive room setup enables the doctor to integrate computer into the consultation with less effort. The physical layout of the consulting room determines whether the patient can see the computer screen and view the data contained on it. If the room layout allows, patients tend to view the doctor's computer screen on a regular basis. In room layouts that do not promote patients to interact with the screen, such episodes are determined by doctor's actions.

Describing the room layout in terms of the screen orientation relative to the patient is useful when studying the doctor-patient-computer interactions. In the exclusive layout, the patient is effectively excluded from interacting with the computer screen at the same time as the doctor. In the semi-inclusive doctor controlled layout the patients wait for the doctor to suggest and facilitate, before interacting with the screen. The semi-inclusive patient controlled setting allows the patient to interact freely with the computer screen while the inclusive layout is associated with more triadic episodes.

8.7.3 Interruptions

Doctors being interrupted during their surgery sessions appear to be a norm. Interruptions mostly occur when patient is in the consultation room. However their durations are longer, if they occur after the patient has left the room. Multiple interruptions could also occur while some result in the doctor leaving the room.

8.7.4 Consultation initiation

The doctor, patient or computer can initiate the consultation agenda. The majority of the consultations are doctor initiated. The computer is responsible in setting the consultation agenda for the least number of occasions. Nevertheless, displaying relatively unsophisticated information by the EPR system appears to change the direction of the consultation. The type of consultation initiator does not have an effect on the amount of overall computer use.

The proportion of consultation time doctors spend reviewing the medical record is significantly increased when computer is involved in initiating the consultation. The capacity of EPR systems to provide sophisticated patient history reminders could define the computers' influence in setting the agenda.

8.7.5 Accompanied patients

Instances where the patient is accompanied by a family member or a friend are common. Having an additional person in the consultation room does not result in an increase in the consultation duration. However, such situations result in reduced computer use. Doctors verbally interact for longer proportions, and they do so largely disengaging themselves from computer use when an additional person is present in the consultation.

8.8 Consultation length

The overall consultation length is not influenced by the EPR system characteristics. This rejects the fifth sub hypothesis; '*The proportion of computer use is associated with the EPR system involved*'. However, the -patient verbal and non-verbal interactions and the quality of the medical record keeping appear to be associated with the design of the EPR system. Consultations with older patients and those conducted by more experienced doctors appear to be longer than those associated with the opposite categories.

8.9 Doctor-patient interactions

Doctors allocate a proportion of the core consultation to directly interact with the patient and dedicate another period to interact only with the computer. There are also periods where doctor-patient and doctor-computer interactions overlap. The content of the EPR system's interface and the amount of attention required to achieve the task influence the verbal interactions doctors undertake and the amount of eye contact they make while using the computer. There are system features that allow doctors to use the computer with little or no influence on the way they interact with patients, while certain system characteristics demand the doctors attention away from the patient. There are also occasions where doctor-computer and doctor-patient interactions are complementary. In overall, findings related to doctor-patient interaction aspect, together with the doctor-computer interaction characteristics discussed in the chapter seven lead to the acceptance of the sub hypothesis 6; '*The quality of the common consultation tasks performed and the ability to support patient centeredness are influenced by the EPR system design features*'

8.10 Principal findings– computer use for reviewing the record

The findings associated with the doctor-computer interactions leads to the acceptance of the set of research hypothesis associated with the specific role of the EPR system. This has been supported by the evidence related to all the common consultation tasks, both by quantitative findings and based on the sequence diagram process models. Therefore, the following three hypothesis are valid; (1) Hs4 - *The type of the EPR assisted task; whether information reviewing, recording or taking actions and whether the tasks are performed before, during or after the patient's visit influence the computer use characteristics*, (2) Hs7 - *The time taken to perform and the process flow associated with the common consultation tasks are linked to the EPR system design features*, and (3) Hs8 - *Process models of common consultation tasks can assist to establish associations between EPR system design features and the characteristics of common consultation tasks*.

8.10.1 Medical record reviewing tasks

Problem oriented organisation of past encounter data supports efficient reviewing of patients' history. Doctors find structured medical records with all encounter details grouped under significant problems and general health profile topics more useful, than chronologically arranged list views. There are also positive influences of interactive facilities for grouping and filtering

When medical record summaries are available within the main consultation interface doctors willingly use them throughout the consultation. This results in reducing the need for navigation within the main consultation interface, to explore different sections of the medical record. Doctors frequently refer to the visible summary information, during doctor patient interactions and when recording data or taking actions using the EPR system. There are also advantages of providing the detailed patient history in a full separate page accessible using *tabbed* navigation. Having a separate, difficult to access encounter detail pages influence encounter reviewing to be done less frequently or for longer durations. Having only a summary view or detailed view accessible from the main consultation area introduces unnecessary stringencies for computer use, doctors benefited when they had the option to select between either of the views

Offering a medical history summary as a reminder message at consultation initiation improves overall encounter reviewing interactions. Doctors refer to such messages when provided in an easy to review structure supported by visual cues.

Embedding documents received from external health care providers using interactive links are far more efficient than having document identifier based navigation approaches. There are advantages of displaying such documents in dedicated interface areas. However if the additional interface has a separate design scheme doctors spend more time interacting with it and trying to move their attention back to the main consultation area.

The doctor's style of consulting or computer use may determine the occurrence of past encounter reviewing tasks. In situations where remote calling-in methods instead of physically meeting the patient, was used there was additional time to review the medical record content. Some doctors, as a practice delayed the patient calling-in interactions until the past encounter reviewing tasks are completed. The type of significant recent problems associated with the patient also has an influence on the time allocated for encounter reviewing. When new test results or documents are visible in the encounter history, doctors have prolonged encounter reviewing episodes.

Room layout influences whether the clinician attempts to review past encounter details with the patient during the core consultation. Patients are reluctant to participate verbally or non-verbally if the doctor is looking at the screen the whole time and content of the screen is not perceptible. Doctor-computer interactions associated with encounter reviewing often overlap with doctor-patient verbal or non-verbal interactions, this is particularly noticeable if encounter reviewing takes place during the core consultation. Doctors may also decide to read-aloud to remind patients about past encounter entries. Free text entries are more associated with such situations. Problem oriented encounter lists support doctors to engage more in conversations aimed at problem discovery. The ability to group chronologically with minimum effort is also helpful when responding to patient comments.

8.10.2 Test or examination results reviewing

Holding test or examination outcomes only as entries of past encounter details limits their usage during the consultation. Also in interface designs where problem orientation has been the central strategy for information organisation, doctors find it challenging to review results associated with multiple problems. The use of tree-menu based approaches for organising test or examination outcomes lengthen the task completion time, particularly if users wishe to review multiple items. Even though there are advantages of grouping numerous sections of the medical record into a compact navigable structure, they are not effective to use in the context of a consultation where users tend to interact with a particular sections of the medical record routinely.

Doctors often interact with the test outcomes available within the past encounter summary, mainly when they are associated with features to filter results. Having the results summarised into a single entry, that is expandable with a single mouse click is the most efficient; doctors review test results with less effort, both before inviting the patient in and during the core consultation. Doctors tend not to leave the main consultation view for dedicated sections with test results, if a usable summary of the test results or examination findings are visible. They prefer to interact with or look at the summary of outcomes frequently instead of performing multiple interactions to access detailed results.

Users also start interacting with test results if graphical icons or function keys exist to easily activate dedicated interface sections. The presence of an entire page with detailed test results, reachable using a navigation tab is more efficient than having a permanently visible sub-window with a small area to interact with. In situations where results are displayed in a separate page, accessing them by typing in reference numbers or searching using terms are less efficient compared to the use of interactive symbols

In most situations doctors spend a considerable proportion of time to obtain a specific view or result set they wish to review. Although, doctors readily explore when results are present within past encounter views, they still spend more time interacting with the interface if details are presented without a structure or sufficient visual cues. Use of readily recognisable graphical symbols or font colours to indicate outcomes that need doctors' attention are beneficial.

Reviewing of test results tend to become a subject of triadic interactions or are associated with situations where screen sharing occurs. These are particularly noticeable in instances where patients inquire about the outcome of a recent test or examination. When reviewing is performed during consultations in rooms with inclusive layouts, doctors tend to use graphical results and often make references to specific sections of the output. In situations, where such interactions are restricted by the room layout, doctors tend to refer to list views of test results and only interpret them verbally.

In situations where screen sharing episodes occur, doctors particularly tend to make reference to high-low values or valid ranges provided by the EPR interface. The ability to filter or group test outcomes enable doctors to make the test results reviewing tasks less intrusive.

8.11 Principal findings – computer use for recording data

8.11.1 Coded or free text data entry

Auto-suggestion of picking list after analysing the text doctor enters reduce the coded data entry initiation time. Use of function keys or availability of a dedicated icon also assists to bring down the task initiation duration. When problem lists are presented in the main consultation interface, flexibility to re-use past problem codes by *copying and pasting* could introduce time savings. There are efficiency gains associated with the use of icons, particularly for adding commonly used classification codes, for example smoking status, alcohol consumption, height and weight.

Interfaces that allow entering of coded and free text data in an integrated manner, allow more flexibility for doctors; they can enter data as they emerge in the consultation without having to plan beforehand. In situations where same input area is used for both types of data entries, doctors swiftly move between coded and free text entry, and vice versa. When such behaviours are supported by interfaces, narrative and coded entries are complimentary. Since coded and free text data entering tasks are frequent and take up a considerable proportion of consultation, facilities that allow users to initiate either of the tasks directly and alternate between them are favourable.

Problem orientated data entering, though result in increasing the amount of coded entries, introduces unnecessary rigidity. Making the code selection a pre-requisite for free text entry results in doctors adding codes with less utility. It also harms the purpose of narrative data entry, where data associated with different aspects of patient history are grouped under a single unrelated code.

Similarly it could force doctors to unnecessarily separate narrative entries, damaging its *story telling* properties.

The ability to view the patient's current medical record in the background enables doctors to contextualise their data entry tasks and organise the record better. Information currently recorded in the medical record especially influences the free text doctors enter.

Doctors expect to spend a limited amount of time for coded data entering, and they mentally seem to pre-select a small list of terms capable of representing their judgement. When lengthy picking lists are presented they tend to re-word the search instead of scrolling through. EPR interfaces that display only the most matching codes are also not constructive; since this may result in hiding less similar however closer fitting terms.

8.11.2 Blood pressure data recording or similar structured entries with small number of elements

Routinely performed data entry tasks with a limited number of associated clinical terms are useful in promoting a conversational style of computer use. *Auto-suggestion* after entering only two characters, use of icons and ability to use existing entries (by *double* or *right* clicking) provide efficiency gains when initiating data entry interfaces. A simple presentation structure in the input data entry fields, with an instinctive direction for navigation amongst them enable doctors to initiate and complete the data recording tasks with minimum effort. Doctors find the availability of past readings or indicators about their progressive changes useful for educating patients. They also support data recording to be more patient oriented.

The use of common data entry forms, only sections of which are used regularly, introduces unnecessary doctor-computer interactions. They are most demanding when the desired data entry action requires an activation of a complex data entry form, and having to navigate across several pages to locate the specific data input fields.

Meaningful placement of the input fields representing the natural consultation workflow and arranging the sequence of interactions to align with doctors' decision making process allow doctors to perform data entry in parallel to verbal interactions. For example, when recording blood pressure data, doctors find placing the input field for systolic blood pressure value over the one for diastolic, in a vertical manner more useful.

8.12 Principal findings – computer use for taking actions

8.12.1 Medication reviewing and comparable tasks for taking actions

The capacity to take actions without having to navigate away from the encounter data introduces more flexibility, enabling doctors to integrate the computer use during the later parts of the consultation more easily. Creating prescriptions is the commonest task that occurs towards the end of the consultation, and reviewing the medication lists appears to be a precondition. Observed interaction patterns suggest that doctors are in favour of a facility that enables them to initiate medication reviewing directly through past encounter details. In particular, it seems to be more productive when the medication lists can be explored through the encounter lists that are arranged chronologically under different problem titles.

EPR users find it easy to explore medication lists presented in a full page, as a substitute for having them presented in pop-up windows or sub windows. Having tab-linked separate pages seem to be the most efficient approach for presenting information useful for taking actions. Facilities for filtering and grouping are also in demand during this phase of the consultation. Most of the verbal interactions at this point of the consultation are related to the plan of actions, and doctors tend to find any lengthy interactions intrusive.

8.12.2 Acute prescribing and other prescription creation or activation tasks

Placement of the text entry fields indicating the most effective data entry sequence using visual cues makes the prescription creation tasks efficient. Combining all related reminders into a single output also contributes to efficiency gains. Patients seem to acknowledge the need for a dedicated computer use segment for creating a new prescription. Similar inferences are apparent for tasks like making referrals, test ordering and writing letters. However, when unnecessary demands are placed by numerous alerts, pop-up windows or interactions steps, doctors tend to ignore, continue with default selections or result in entering invalid data. The latter situation demands more doctor-computer interactions to make corrections or to re-start the task.

Regular display of reminder messages linked with routine tasks does not receive the doctor's attention per se. Interactions doctors perform subsequent to the reminder messages are mostly aimed at taking the input focus back to the main interface. Message structure and the use of font decorations appear to play a significant role. Displaying the reminders overshadowing the main consultation area detaches doctors from the contextual information; they are not able to access the necessary background information to place and consider overall effect of the current action. Doctors attempting to look-up additional information contributes to lengthen the overall interaction time. There are advantages in getting users to familiarise with a visual structure in a reminder message, so that they can directly give attention to the most critical sections without having to review the entire content.

8.12.3 Prescription issuing and performing similar routine tasks associated with tasks closure

Doctors do not seem to set aside time for interactions associated with task completions, especially those that occur towards the consultation closure, such as prescription issuing or test request printing. When there are numerous interactions or alerts associated with prescription issuing, they appear to make a significant influence on the doctor-patient interactions. When selection of items is involved, check box based approaches are more demanding than having text links. Visually indicating the selection, especially by highlighting the entire item increases usability. At this point of the consultation, doctor usually performs final tidying up of the medical record content and may find the pop-up messages reporting on background tasks such as document printing status, as disrupting.

8.13 Implications for consultation analysis research

It is possible to extend the three element framework (context, time, process) used for the designing this study and presenting the outcomes, into a classification system with eight core elements. These eight elements portray the aspects that are instrumental in interpreting outcomes of a consultation analysis research. They are also useful in designing a new research study. The following are the aspects represented by each element of the framework.

(1) Theoretical and methodological approach to observation

The theoretical or methodological background from which observations are made is an important aspect of a consultation analysis research. For example, a software engineer may design a use-case associated with a clinical system and define an '*Actor*' as a person, with a specific purpose, interacting with a certain aspect of that system (Cockburn A, 2001); whereas an '*Actor*' may mean something completely different to a social scientist using a dramaturgical framework, describing the consultation as a stage.

(2) Data collection

There should be a clear statement of the type (e.g. direct observation, video recording) and method (e.g. participant observation, multi-channel video recording) of observations and other types of data collection techniques used.

(3) Room layout

The layout of the clinician's office is critical in physically allowing or not allowing the patient a view of the screen and the potential to interact with it.

(4) Initiation and interaction

Who initiated the consultation; how the participants interacted; and the nature of the doctor-computer-patient relationship. Interactions can be complex: patients are often accompanied and the clinician can be interrupted.

(5) Information and knowledge utilisation

The information managed in the consultation is a combination of what the patient says and communicates; what information is contained within the medical record and information sources.

(6) Timing and type of consultation variables

There are currently no standard descriptive terms used to describe the consultation and to allow comparison of duration and description of continuous activities (e.g. speech, eye contact) and episodic ones, such as prescribing.

(7) Post-consultation impact measures

Though not used in this study, there are a wide range of tools which can be used for post-consultation assessment, including satisfaction surveys, and health economic assessments based on the perceived quality of the clinician-patient interaction.

(8) Data capture, storage, and export formats

Multiple files in proprietary or legacy format makes sharing of research outputs difficult. Facilities to merge and analyse data from multiple data collection approaches, and research studies in anonymised form should exist. As utilised in this study, XML has the potential to support the development of shareable rich information repository.

Activity/element	Descriptors
1. Data collection	(1) Audio only/Audio-visual/ Non-video/Other (2) Number of channels and observation devices, (3) Coverage of each channel – wide or targeted, (4) Type and physical profile of intrusive devices, (5) Automated measurement techniques used, (6) Steps for setting up, (7) Steps for analysable data extraction
2. Room layout	(1) Inclusive, (2) Semi inclusive – clinician controlled, (3) Semi inclusive – patient controlled, (4) Exclusive
3. Theoretical and methodological approach to observation	(1) Qualitative, quantitative, technical, *(2) Macro or micro theory,* *(3) Cognitive theory* *(4) Cognitive load* (5) Communications skills and consultation models
4. Consultation initiation and interaction	(1) Consultation Initiation- clinician, patient or computer, (2) Use of computer – minimal, block, conversational, (3) Clinician usual orientation – unipolar, bipolar, (4) Clinician behaviour style – engaging, disengaging, cogitating, (5) Interaction: Triadic or Dyadic: patient-clinician or clinician-computer (6) Use of computer: excluded, controlled, shared, (7) Direction: synchronous, asynchronous, (8) Nature of patients-computer interaction: screen controlling, watching, sharing, (9) Influence of computer: informative, prompting, distracting, engaging
5. Information and knowledge utilisation	*(1) Information: Source, usefulness, outcome* *(2) Computer: information, facilitation, agenda,* *(3) Clinician: Knowledge, facilitation, training, agenda,* *(4) Patient: Problem, knowledge, agenda*
6. Timing and type of consultation variable	(1) Greater consultation: First to last interactions, , (2) Marginal – before and after patient present; and Core - patient present, (3) Bilateral actor times - three actor time and Uninterrupted three actor time (4) Consultation interaction variables - continuous, episodic and singleton
7. Post consultation impact measures	*(1) Measurement of adherence,* *(2) Satisfaction with consultation,* *(3) Clinical indicators and health outcomes,* *(4) Think-aloud protocol explanation of interaction (replaying video)* *(5) Post-consultation interviews*
8. Data capture, storage, and export formats	(1) Process – automated, semi-automated, subjective manual, (2) Tools and applications used – (a) Direct: installed, plugged-in, external or (b) indirect observation, (3) Raw data format – including log file (i.e. time log) or not, (4) Data representation – quantitative, graphical, (5) Computer use – screen, mouse (coordinates), key board use (navigation & active key use, (6) Description of IT use - navigation, transition (between functions within EPR), operational use: data values and descriptors (7) Data storage format and mechanism for navigation and linking research output to source data (8) Export formats: Extensible mark-up language (XML); or standard modelling formats (e.g. Unified Modelling Language (UML))

Table 8.2*:* Classification framework with eight elements to describe characteristics of a consultation analysis research

8.14 Implications to clinical system design

This research provides a number of novel findings associated with the information system use in the consultation setting. The diverse nature of the consultation tasks observed is useful in uncovering a considerable number of user practices and usability issues that could potentially benefit clinical system designers. The principal findings discussed thus far indicate aspects of EPR system designs that can be improved, characteristics that are not fitting for the consultation setting or those that need re-engineering. However, it should be emphasised that all EPR designs investigated in this research are capable of supporting the consultation, albeit their ability to blend in with social interactions is debatable. Each system seems to have achieved '*fit for purposeness*' to various degrees, pertaining to certain consultation tasks. Therefore, the implications for clinical system design are best recognised by exploring the best features of each design approach. At the same time the capacity of those '*best features*' to function together as a coherent system should also be appraised. Box 8.1 below lists the recommendations for system design under the three main computer use categories.

Recommended overall design features

- Facilities to manage demands from interruptions - doctors able to break computer use momentarily and to resume with less effort.
- Keyboard based activation and navigation for routine tasks
- Optimal use of icons, grouped by a structure reflecting the consultation process (i.e. SOAP headings)
- Customisable views, linkable to user login details
- Shareable views – opportunistic use of triadic episodes for engaging patient
- Context aware prompting – displaying of picking lists and supportive information compatible with existing medical record content
- Supporting conversational computer use – less demanding task initiation, non-intrusive prompting
- 'Keyboards for consulting' - Computer keyboard with dedicated function keys. Colored keys for consultation headings, activation of BP recording or prescribing (such approaches are visible in point of sales systems or similar information systems customised for routine tasks)

Providing facilities to support medical record reviewing tasks

- Encounter summary present in the default view.
- Encounter details readily accessible from any location in the EPR system.
- A direct path to move between detailed and summary view of encounters.
- Supporting both problem oriented and chronological ordering of encounter information, with facilities to filter.
- Ability to customise the content of the patient summary prompt, and enable/disable based on preference, and to define rules about their presentation
- Keyboard based navigation within list views
- Uncluttered, optimally partitioned and easily navigable viewing areas.
- No complex navigation structures (navigation trees, multiple selections) and inconsistent activation options
- Test or examination results, letters from other HCPs contextualised by associated encounter summaries or facilities for simultaneous viewing

Recommended features to support data recording tasks

- 'Context aware' auto-suggestion techniques- based on previous recordings, current problem title, active problems, and consultation heading being used.

- Supports conversational recording of free text and coded items, and ability to structure/organise them later in the consultation when the problem is established.
- Problem codes linked with reference materials/images/knowledge based articles for easy sharing with patients
- Systems to be aware of search term re-wording attempts and to automatically suggest comparable terms or offer extended picking lists without requiring extra manual navigation
- Picking lists to behave as 'weighted list' based on code popularity, associated data quality issues and the content of the current view, with possibility of switching to a 'tag/word cloud' view to recognise the inter-relationship between codes
- Global and dynamic rule sets to validate code presentation and selection, i.e. avoid situations like offering 'never smoked' as a code when patient has already been coded as a smoker.
- Free text entry and coded entry input integration, swift transferring between two entry modes.
- 'Selective' problem orientation, with capacity to customise its activation based on consultation heading, problem type or consultation type.
- Validation rules for examination results entry, basic error corrections, and unit selection
- Smaller number of input areas in data entry forms- supports both flexible movement patterns and desirable movement paths.
- Structured free text entry areas linkable to problems, reference materials, guidelines and care pathways.
- Facilities to directly annotate and link test/examination results
- Facilities to re-use and modify previous coded or free-text entries using 'drag and drop'; 'point and click' or menu based methods are too demanding.

Recommended features to support computer use tasks associated with taking actions

- Common and consistent patterns for common tasks such as prescribing, test ordering.
- Provide an overview of the current record to relate decisions to the consultation's progress
- Ability to switch to a sharable summary view, to support discussions about 'next steps' with patients
- Prescribing data entry with vertically ordered input areas- facilitates swift movement between input fields.
- Single structured prompt for each medication, display only if concerns needing Dr's attention exist.
- Ability to do individual or multiple prescriptions at any point with immediate or delayed issuing
- Presenting the current medication list in the default view with facilities to filter based on prescription type
- Default view to indicate an easily recognisable summary to support consultation closure - problem establishment, associated actions and plans for follow-up
- Dedicated function keys to support more keyboard driven tasks
- Customisable global views, interaction patterns and rule sets linkable with user's login details - different GPs have different styles

Box 8.1: Recommendations for clinical system design tasks based on the findings from this study (elements and descriptors in italic text have not been explored in this study, however have been indicated in the literature review)

8.15 Comparison with existing literature

The existing methods for analysing consultations activities are more subjective (Schade *et al*, 2006). Some qualitative studies have looked into the behaviours associated with doctor-computer interactions using a single channel approach followed by tagging of the video (Pearce *et al*, 2006). Previous attempt to look into the multitasking in consultation have combined a video analysis and conversation analysis method (Gibson *et al*, 2005). A cognitive based observational approach to analyse the data entry by clinicians in an outpatient setting has used a much complex set up; a portable usability laboratory with a video converter, microphone for conversation and key board sound recording (Cimino *et al*, 201). The author is unaware of any technique similar to ALFA which provides such precision of observation (appendix A).

Investigation methods in human computer interaction (HCI) use multiple observation methods, however are often synthesised into a single visual data stream (Blandford and Vanderdonkt, 2001; Oviatt *et al*, 2003). They lack any quantifiable measurements flexible enough to code variety of consultation system interactions. There are also techniques used in cognitive sciences with various levels of sophistication (Theadom *et al*, 2003). When such techniques are used for consultation analysis, they primarily focus on cognitive loads, user perception and attention. Although the study of the human computer interaction (HCI) is a well developed discipline, it focuses on the interaction between one or more individuals and one or more computer systems (ACM SIGCHI, 2008). In HCI research user-computer interaction is the main focus. In contrast, this research has been aimed at developing a toolkit to capture the complex social interaction of the consultation within which the clinician-patient activity is pre-eminent. Staggers & Kobus (2000) reported that nurses found GUI interfaces enhanced their performance and satisfaction. Krushniruk (2009) has suggested a framework for testing the safety of systems, which might be done using a toolkit such as ALFA.

Access to information has been acknowledged as playing a pivotal role in the conduct of the consultation (Hersh, 2005). Prompts and reminders which were observed in this study as demanding doctors attention, in fact have a significant role associated with clinical guidelines and (Foy *et al*, 2007) evidence-based practice (de Lusignan *et al*, 2003). Doctors tend to consider ability to provide information about medication or presenting details reminding about medications and interactions as routine tasks associated with EPR systems (Yu *et al*, 2010; Hug *et al* 2010). To support clinical practice, it has been acknowledged that providing feedback accompanied by contextual data with sufficient time to reflect on as having a positive influence (de Lusignan *et al*, 2007).

Previous studies have examined the consultation as a whole but only Pearce *et al* (2008) has examined the influence of the consultation initiation. Other researchers have also discussed various behaviours associated with doctor-patient-computer elements and how certain potentially useful information is missed by doctors (Ventres *et al*, 2006; Booth *et al*, 2004). The possible influence doctor's computer use could have on the doctor-patient interactions has been discussed previously (Western *et al*, 2001).

Even though the importance of information to support decision making has been considered as a desirable feature, over supply of information could have a negative influence. 'Cognitive dissonance' could result in doctors taking the consultation in an unexpected direction, and may even totally avoid interacting with the computer (Robinson *et al*, 2003). The impact of Quality Outcomes Framework (QOF) computer prompts on the consultation has previously been investigated both qualitatively and quantitatively (McDonald R and Roland, 2009; Moulene *et al*, 2007). However, these studies did not include live consultations.

Quantitative methods used for consultation research are closely associated with social exchange theories, such as the Roter Interaction Analysis System (RIAS) (Margalit *et al*, 2006). The SEGU framework also considers the consultation setting and information exchange as important characteristics (Makoul, 2001). It has elements associated with setting the stage, eliciting and giving information, understanding the patient perspective and ending aspects of a consultation.

There is a lack of literature emphasising the significance of doctors actively incorporating the computer consultation process. It is possible that the unavailability of system analysis and design techniques compatible with the often unpredictable and complex consultation environment is the root cause for interface designs found in the EPR systems investigated here. The lack of attention given to the usability aspects of EPR systems has been discussed before (Krause *et al*, 2010; Pearce *et al*, 2010). Consultation research has regularly focused on interactions, sometimes adopting ethnographic approaches (Ventres *et al*, 2006). Conversational analysis frameworks focusing on audio recording of doctor-patient interactions have also been used. In terms of theoretical frameworks, Grounded, Systems and Structuration theories have been previously employed to design and interpret information captured by observing consultations (Robb and Greenhalgh, 2006).

Non-verbal communication, particularly the direction of gaze can have a significant influence on the consultation. There have been discussions on how computer use can alter non-verbal interactions (Rhodes *et al*, 2008). A previous study reported the average proportion of computer use within a consultation as 16% (Bui *et al*, 2005). The doctor controlled semi-inclusive layout reported in this as the commonest is also reported as the commonest layout by Schade *et al*.(2006).

8.16 Limitations of the study

The most significant criticism of consultation observation is the Hawthorne effect, the suggestion that the act of observing changes the interaction. Whilst undoubtedly this does occur, the impact on research is impossible to quantify. Although some of the doctors appeared to be conscious about the presence of video cameras, particularly at the initiation of the very first consultation of the recording session they took part in, no observable effect could be noticed in their conduct in general. Also, discussions the author had with those doctors suggest that there is little Hawthorne effect. Their opinion was that the demands placed on them during each consultation and the work pressure associated with time keeping as overshadowing any concerns associated with being observed. Observational research generally does not lend itself to large samples. In addition, over time, the video recording methods used are becoming more unobtrusive, lessening the impact of observation itself, while still adhering to ethical review and institutional review boards. Large studies will only involve 20-30 clinicians and usually less than 200 consultations; therefore triangulation with other methods and findings from other studies are needed prior to asserting the generalisability of findings.

Gaze can be difficult to assess. Even using the camera view focusing on the doctor's upper body, it is difficult to interpret the where doctor is looking at; room layout also has an influence on this. Even though the three camera setup provides additional recording to triangulate direction of gaze compared to a single camera approach, it is time consuming to measure unless done as a dedicated rating run. This is more difficult to perform if the doctor is wearing spectacles or doctor's face is shadowed due to a background light.

There is also scope to conduct post-consultation interviews and immediately replaying the video using techniques like "Think aloud protocol" to gain further insights into the consultation process. The clinician-patient relationship remains the cornerstone of medical practice and has a great impact on a number of post-consultation outcomes, such as patient satisfaction and adherence to recommendations. A good clinician-patient communication also impacts significantly on the patient's decision to follow recommendations. There is increasing evidence that the clinician can help the patient improve adherence to medical recommendations, by improving aspects of trust and involvement in the decision making process. This can then be linked to post-consultation outcomes using validated tools to measure adherence (Morisky et al, 2008), patient satisfaction, and general health outcomes (Shachak et al, 2009). Obtaining feedback from the doctor and patients who participated in this study could have provided useful data to intercept more qualitative aspects of this research domain.

The control this study exerted on compounding factors was limited due to the fact the observation study used a sample of real life consultation. Due to technical difficulties, the UAR output could not be obtained for some consultations. Even though the possibility exist for them to be re-created based on the screen capture data they might not represent the exact keyboard and mouse use data.

Also it is not realistic to assume that this study is representing the features associated with the full range of general practice consultations. The clinicians filmed may not be representative of practitioners as a whole across the health system. Considering the number of factors that could vary across the larger number of general practice consultations that take place, we may not have identified all possible contextual elements.

8.17 Further research

How the clinician-patient-computer relationship evolves during the consultation remains a 'black box' for many researchers; with a lack of understanding as to what elements of use of IT change or modify health behaviours. More evidence is needed to shed light on this important area and video studies provide important insights.

The research data set created as a result of this study has wider utility; there are more interactions that can be coded, derived and potential exist to analyse their inter-relationships under number of research themes. Analysing the consultation transcripts could provide useful data for conversation analysis research. The XML outputs provides a readily usable analysis data set, however their utility need to be tested by a third party.

Further simulation based studies focusing on the influential electronic patient record features identified from this research could potentially provide more specific information about their functions and recommend strategies for improvements

The eight element classification, whist representing the current state of the art, is still in its infancy in terms of development. Whilst many studies describe what they see, few have moved beyond to the implications of what is being observed. This work can be used to explore more advanced concepts such as the changes in power and authority in the consultation, the implications of different clinical systems and usability design and so on. Practical feedback from such studies can include system redesign and customisation to facilitate usability, design of more effective clinical workflow involving technology, improved ergonomic layouts, and improved IT training.

As the role of electronic information expands, so too must the research. Additionally, observational data and the task classification used in this study can be used at a much higher level of analysis on larger samples, enhancing the generaliseability of the findings.

8.18 Conclusions

A proper medical record is the underpinning of the computerised health care system. The existence of a useful record depends on the interactions that transpire within a consultation and that interaction is often a three way communication between doctor, patient and computer. This study aimed to explore the consultation process from a view that quality interaction is a pre-requisite for excellent patient care, and that all else follows on from it. The interactions observed in this study were extremely complex and indicate how the computer is not the primary focus of the doctor and is often a distracting informant. The primary research hypothesis defined for this study acknowledges the capacity of multi-channel video based observation techniques to explore the content and features of the general practice consultation, to delineate the associations between EPR system characteristics and consultation process. Findings from this study accept this main hypothesis. A further set of sub-hypothesis has been used to elaborate the research question and to recognise the specific details of the relationship between the clinical tasks and the use of computer, Except the hypothesis related to the proportion of computer use, all others are proven to be acceptable by the results. The rejected hypothesis indicates a phenomenon with considerable implications. It implies the clinicians' tendency to use the EPR system for a consistent proportion regardless of the functionalities or the usability aspects linked to the system. The acceptance of all other hypothesis mean, the way in which clinicians carry out their computer assisted consultation tasks are different, partly influenced by EPR system characteristics, however without letting the proportion of the system used to beaffected.

The ALFA multi-channel video recording based observation tool-kit developed in this study is capable of capturing a comprehensive overview of a computer supported consultation. Direct observation of the clinical consultation using the ALFA toolkit is acceptable to patients. It captures the context of the consultation, the precise timing and duration of key tasks, and produces an output software engineer can interpret.

This research proposes a framework with three elements to analyse computer supported clinical consultations; (1) the overview of the context within which the consultation is conducted, (2) time taken for common consultation tasks and (3) the workflow associated with those activities. The occurrence of common tasks, their distribution within the consultation time line and composition vary. Aspects of these task variation and the underlying causes are not prominently acknowledged by the existing theoretical models of consultation. This study establishes the need for conceding this variation as an essential condition for interpreting the influence of computer on the consultation.

Comparing the common consultation tasks across different electronic patient record systems indicate workflow differences that are attributable to the design characteristics of the system. The UML sequence diagram process models of common tasks provide analysable insights into their process structures. They support delineating of workflow characteristics linked to the information system design features. Understanding the association between the information systems constructs and the conduct of the consultation is useful; to asses, evaluate and control the impact of the technology. The potential exists to manipulate the information system designs to direct this impact positively, to facilitate the consultation to be more patient centred.

Reducing the time needed for initiation the computer use tasks and for exploring of useful information could save time and make computer use less intrusive. The framework for consultation analysis introduced in this study may assist system designers to understand better ways of incorporating the computer into the consultation and for doctors to see the computer as a resource to share with their patient.

To use the computer effectively requires a change in the consultation room layout allowing the patient to see the screen content. There is a need to have consultation room layouts and theoretical models of consultation accepting the computer as a key entity. Those clinicians who engage in screen sharing and have triadic moments with patient may possibly record and code more useful data in their computer.

It is futile to assume that all clinical systems are the same or only one system is effective in supporting a consultation. It is far more useful to explore what represents the "best" features of a clinical computer system and using that understanding to support system development. System designers need to recognise that the computer is used for a consistent proportion of the consultation, and if it is inefficient doctors tend to record less or poor quality data rather than prolonging the computer use until the best outcome is achieved. EPR systems also need to be able to cope with interruptions and support consultations where patient is accompanied. Future development of EPR systems should be based on direct observation of the consultation. A small range of simulations could then test all the EPR systems abilities to support or inhibit common consultation tasks.

This study shows that the computer can influence the content and direction of the clinical consultation. Context within which the consultation is conducted could also modify the consultation workflow. Doctors and system designers need to be attuned to these possibilities. Understanding the precise details of this impact, exploring their characteristics collectively with the associated contextual attributes could inform the selection of the electronic patient record system features and agenda for their development. Information systems that can be integrated into the consultation with less effort are likely to enable doctors to maintain a better social interaction with their patients and have a clinical record with increased utility.

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Appendix A – ALFA compared to other techniques

ALFA elements/ functionality	ATLAS.ti	NVivo	DRS	Transana	Morae	Camtasia	Adobe Captivate	BB F'Back	ALFA
1. Multi channel Video (MCV) recording									
Screen capture	N/A	N/A	N/A	N/A	Yes	No	No	Yes	Yes
Video capture	N/A	N/A	N/A	N/A	1 camera	No	No	1camera	3 cameras
Audio capture	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes
2. Observational Data Capture (ODC)									
Multimedia file import	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Sufficient video display area	Yes	Yes	No	No	No	N/A	N/A	N/A	Flexible
Video playback controls	Yes	Yes	Yes	Yes	Limited	N/A	N/A	N/A	Yes
Direct export of interaction durations	No	No	Yes	No	No	N/A	N/A	No	Yes
Method of coding for interactions	Codes, Memos	Codes, Memos, Nodes	Codes, Text	Keywords, Comments	Markers	No	No	No	Duration variables
Interaction durations visible	No	Yes	Yes	No	Yes	No	No	Yes	Exports directly
3. User Activity Recording (UAR)									
Computer keyboard use	N/A	N/A	N/A	N/A	Yes	No	No	Yes	Exports directly
Computer mouse use	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Exports directly
Interaction durations	No	No	Yes	No	No	No	No	No	No
Lightweight to install & run	N/A	N/A	N/A	N/A	No	No	No	No	Yes
4. Voice Activity Recording (VAR) and transcription									
Indicates voice levels	No	No	Yes	Yes	No	No	No	Yes	Yes
Measures verbal interactions	No	Manual	No	Manual	No	No	No	Manual	Exports directly
Import/create transcriptions	Yes	Yes	Yes	Yes	No	No	No	No	Yes
Time stamped transcriptions	No	Yes	Yes	Yes	No	No	No	No	Yes.

ALFA elements/ functionality	ATLAS.ti	NVivo	DRS	Transana	Morae	Camtasia	Adobe Captivate	BB F'Back	ALFA
5. Log File Aggregation									
Combine data from different tools	video & transcriptions	video & transcriptions	Video, transcriptions & log files	video & transcriptions	Screen capture & video	No	No	No	Up to 10. Can extend further
Single exportable file	Yes	No	No	No	No	Yes	Yes	Yes	Yes, many formats
XML output	Yes	No	Limited	No	No	No	No	No	Yes
6. Occurrence graphs									
Time lines for interaction	No, Network diagrams	Yes, small display area	Yes, small display area	No, Clips organised with labels	1 timeline	No	1 timeline	mouse, keybrd' & voice	Multiple timelines. Large display area
Interactions mapped to video	Yes	Yes	Yes	Yes	Yes	No	No, to screen capture	No, to screen capture	Yes
Interaction durations linked to video segments	No	Yes	No	No	Yes	No	No, linked to frame	No, linked to frame	No
7. UML process modelling									
Use for UML validation	Limited	Limited	Limited	No	Limited	No	No	No	No
Indicates interactions and durations in channels	No	Yes, limited by display area	Yes, limited by display area	No	Yes, 1 at a time	No	No	Only for mouse, keyboard & voice	Yes, multiple channels of interactions
Shows interaction type directly	No, Using codes	Yes	No, Using codes or text	No. Using labels	No, Using markers	No	No	Mouse, keyboard & voice	Yes. For all recorded interactions

Appendix B – Interaction definitions used for this study

ODC - Continuous interactions

Interaction	Definition and inclusion/exclusion criteria	Key
1. Computer use		D
The clinician interacting with the computer system to carry out any task related to the current consultation.		
Includes Active use of the EPR or any other software application or any other electronic resources related to the tasks of the current consultation. Interacting with the EPR system through the computer monitor and other connected peripheral devices (i.e. Keyboard, mouse and printer). Having verbal or no-verbal interactions with the patient while looking at the computer screen or while using/having hand/s on the computer keyboard or mouse. Dealing with delays/errors with the computer system. Clinician spending an unnecessary amount of time within a functional area of the EPR system that is designed for data entry. Unnecessary amount of or meaningless transitions between functional areas, windows, tabs and data items. Data entry interactions that are not committed saved or submitted to the EPR.		
Excludes Active use of the EPR system or any other application for the tasks not related to the current consultation. Processes/activities that occur in the EPR system when the clinician is not looking at the monitor and not using the computer keyboard and mouse, but as a response to interactions clinician initiated. Interruptions (see definition 27).		
2. Clinician looking at the computer monitor		R
The clinician looking at the computer system's monitor to carry out any task related to the current consultation.		
Includes Looking at the computer screen when it is displaying the EPR or any other software application or electronic resources related to the tasks of the current consultation. Having verbal or no-verbal interactions with the patient while looking at the computer screen. Dealing with delays/errors with the computer system. Looking at the computer screen when the clinician is not seated, or during examination tasks. Looking at the appointment screen within the consultation duration (see definition). Looking at the screen while Interacting with the computer keyboard or mouse.		
Excludes Looking at the computer screen to perform tasks not related to the current consultation. Changes that occur in the EPR system interface after clinician has stopped looking at the screen, but as a response to interactions clinician initiated. Interruptions (see definition 27).		
3. Clinician talking to the patient		S
The clinician talking to the patient.		
Includes Clinician's verbal communication towards patient representing the occurrence of a meaningful sentence or a response. Thinking aloud and writing aloud activities, when patient is present. Natural pauses in the conversation. Clinician talking during examinations. Short verbal interactions. E.g. yes/no answers Verbal interactions that may not be having meaning in its written form but if it is evident to be making a significant contribution to the conversation. E.g. hmmm sound. Observable verbal interactions from clinician towards the patient even when either of them is not visible in any of the camera views. In situations where patient is accompanied by another person/s, both should be considered as a single patient entity.		
Excludes Clinician talking when the patient is not inside the consultation room. Verbal interactions during third party Interruptions (see definition 27). A pause in the verbal interaction that represents a noticeable break in the sentences, and if the clinician is giving attention to another activity, e.g. trying to read something on the screen Doctor talking during third party interruptions.		

4. Patient talking to the clinician	K
Patient talking to the clinician.	
Includes Patient's verbal communication towards the clinician representing the occurrence of a meaningful sentence or a response. Natural pauses in the conversation. Patient talking during examinations. Short verbal interactions. E.g. yes/no answers Verbal interactions that may not be having a meaning in its written form but if it is evident to be making a significant contribution to the conversation. Observable verbal interactions from patient towards the clinician even when either of them is not visible in any of the camera views. In situations where patient is accompanied by another person/s, both should be considered as a single patient entity.	
Excludes Verbal interactions during third party Interruptions (see definition 27). A pause in the verbal interaction that represents a noticeable break in the sentences. Patient talking during third party interruptions. Patient talking when the clinician is not inside the consultation room. In situations where patient is accompanied by another person/s, both should be considered as a single patient entity and verbal interactions between them should be excluded unless they are done in response to a question from the clinician.	
5. Clinician looking at patient	**E**
Clinician looking directly at the patient with the potential of having eye contact.	
Includes Looking at the direction of the patients face while talking or as an act of nonverbal communication. Natural gaps in eye contact while maintaining gaze appropriate to the context of the verbal interaction. Looking at the direction of the patient during the computer use (see definition for D) . Looking at the patient when either the clinician or patient is standing up.	
Excludes Looking at patient's face or eye as part of an examination process. Looking at patient during third party interruptions.	

ODC – Singleton and Episodic interactions

Episodic interactions may belong to either of the two types of bi-actor interactions;

Clinician-computer interactions or clinician – patient interactions

1. Blood pressure recording
Recording the values and associated data related to a single episode of blood pressure measurement.
Includes Activating the blood pressure recording interface. Entering data for systolic and diastolic blood pressure values. Recording of other data items related to the blood pressure measurement, if requested by the EPR system as part of the same data recording interface. Responding to any prompts associated with the blood pressure recording. Correcting errors or making changes associated with the blood pressure data entry. Adding/saving/committing the newly entered blood pressure measurements. Verbal or non verbal interactions occurred during the blood pressure recording interaction if no gap in computer use (see definition for D) related to blood pressure recording is evident System delays, if the blood pressure data recording process is not abandoned. Blood pressure recordings done using a structured data entry form/template. Free text entry associated with the blood pressure data entry interface.
Excludes The physical process of blood pressure measuring. Interruptions (see definition 27). Any break in computer use (see definition for D) . Blood pressure recordings that are not added/saved/committed to the EPR.
Start The first interaction with the keyboard or mouse to move the input focus away from the current location, to initiate the interface for recording of the blood pressure measurements. For keyboard based interactions where blood pressure data entry interface is called up using keyboard commands, this is marked by the pressing of the 'function key' or the 'short cut key/s' to activate the blood

pressure recording interface.
For keyboard based interactions where blood pressure data entry interface is called up using 'text links', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus.
For mouse based interactions where blood pressure data entry interface is called up using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer, away from the current input focus.

End
The first visual affirmation given by the EPR interface indicating that the values related to the blood pressure recording are added to the patient's EPR.
If the blood pressure data entry is done into a 'pop-up window' or 'sub window' or data entry form interface without any other unrelated data entry fields, this is marked by the disappearance of such data entry window/form.
If the blood pressure data entry is done into an interface which also contained other unrelated data entry fields, this is marked by the 'input focus' moving away from the last blood pressure related data entry field.

2. Coded data entry

Recording a coded data item.

Includes
Generic steps for coded data entry;
Activating the coded data entry interface
Typing in the search term
Reviewing the list of codes presented by the EPR system
Selecting and confirming the chosen code
Adding/saving/committing the code to the EPR
Activating the coded data entry functionality.
Entering a coded data item using any version of READ coding system or any other coding system available in the EPR system.
Direct entry of READ code values without going through the generic steps of coded data entry.
Pasting-in codes from the past coded data entries without going through the generic steps of coded data entry.
Entering a coded data item by accepting default values offered by the EPR system, without going through the generic steps of coded data entry.
Coded data entry done in the 'Prescribing/Therapy/Medication' sections of the EPR.
Correct any errors associated with the coded data entry.
Multiple attempts of coded data entry if they are related to the same coded data item and performed without a break in the computer use (see definition for D) .
Responding to any prompts associated with the coded data entry.
Verbal or non verbal interactions occurred during the coded data entry interactions if no gap in computer use (see definition for D) related to coded data entry is evident.
Coded data entry done using a structured data entry forms/template.
System delays, if the coded data entry attempt is not abandoned.
Time taken to link the coded data item with the encounter or problem, if it is done as part of the coded data entry process.

Excludes
Free text data entry linked to the coded data item.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .
Coded data entries that were not added/saved/committed to the EPR.

Start
The first interaction with the keyboard or mouse to move the input focus away from the current location, to initiate the coded data entry function.
For keyboard based interactions where coded data entry function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s'.
For keyboard based interactions where coded data entry function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus.
For mouse based interactions where coded data entry function is initiated using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer, away from the current input focus.

End
The first visual affirmation given by the data entry interface indicating that the chosen coded data item is added to the EPR.
If the coded data entry is done into a 'pop-up window' or 'sub window' or data entry form interface without any other unrelated data entry fields, the interaction end is marked by the disappearance of such data entry window/form after a successful entry.
If coded data entry is done into an interface which also contained other coded or unstructured data entry fields, the interaction end is marked by the 'input focus' moving away from the newly added coded data item.

3. Clinician not in the consultation room

The length of time clinician is not physically present in the consultation room.

Includes Physically leaving the room at any point of the consultation after the start of the consultation (see definition for 'consultation start') and before the end of the consultation (see definition for 'consultation end'). Leaving the room to invite the patient in at the start of the consultation. Leaving the room to get documents, equipments or other accessories needed for the ongoing consultation. Leaving the room to walk out the patient at the end of the consultation. Leaving the room to seek assistance from colleagues for the ongoing consultation. Leaving the room as a result of third party interruption.
Excludes Moving away from all camera views but physically still present in the consultation room. Examining patient away from the camera views or in an area covered by curtains.
Start The first visual or audio indication of the clinician leaving the room. If the door is visible for any of the camera views, this is the instance clinician walks out from the room. If the door is not visible for any of the camera views this could be the sound of door closing if noticeable. If neither a visual nor audio indication is noticeable of clinician leaving the room, this should be the end of the last observable indication of clinician's presence in the consultation room.
End The first visual or audio indication of clinician entering the room. If the door is visible for any of the camera views, this is the moment clinician walks into the room. If the door is not visible for any of the camera views this could be the sound of door opening if noticeable. If neither a visual nor audio indication is noticeable of clinician leaving the room, this should be the start of the first observable indication of clinician's presence in the consultation room.
4. Reviewing the past encounters
Reviewing the list of encounters recorded in the EPR system related to the current patient.
Includes Activating any encounter lists or interfaces with encounter data. Changing the view or navigate into an already initiated list of encounters. Reviewing the documents attached into the encounter view, including the time taken to open and close such documents. All encounters related to the current patient regardless of the type of the health care professional (HCP) involved. Reviewing of encounter data presented as headings, detailed views or as summary views. Reviewing lists of test results and examination results if shown within the encounter list view. Looking at encounter details presented in sub windows. Time taken to navigate amongst encounter items and other activities related to manipulation of the encounter list view including sorting, filtering and querying actions. Verbal or non verbal interactions occurred during the encounter reviewing if no gap in computer use (see definition for D) is evident.
Excludes Encounter summaries shown within the prompts presented when the patient's EPR is loaded. Interruptions (see definition 27). Any break in computer use (see definition for D) . Reviewing of list of test results and examination outcomes displayed as separate lists.
Start The first interaction with the keyboard or mouse to move the input focus from the current location, to any view with an encounter list. For keyboard based interactions this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or the first use of the 'cursor arrow keys' to move away from the current input focus with the aim of obtaining the encounter list view. For mouse based interactions this is marked by the first visible movement of the mouse pointer, away from the current input focus to interact with the relevant 'icon', 'menu item', 'text link' or 'tab'.
End If the encounter reviewing is ended with a break in the computer use, this is marked by the instance the clinician stops looking at the screen. If the encounter reviewing is ended by moving away from the encounter list view, this marked by the disappearance of the encounter list.
5. Physical examination
Preparing for, performing and finishing a physical examination activity.
Includes Physical examination process including the verbal and non verbal interactions. Examinations done within the sight of the camera views or away from cameras or behind the curtains. Time taken to prepare the equipments, furnishings and fittings needed for the examination process. Time taken by the patient to prepare before and after the examination. When multiple examinations are done without a break, this represents the total time spent.

Excludes Durations the doctor is not in the room (see definition). Interruptions (see definition 27). Durations of the computer use (see definition for D) .
Start The instance that the clinician verbally or non-verbally declares the intention to perform the examination immediately before the examination process.
End If the examination is done away from the camera views, interaction end is marked by the event of either the clinician or the patient retuning to their chairs. If the examination process is visible in the camera view, this is marked by the end of the physical examination activities.
6. Reviewing of examination findings
Time spent by the clinician reviewing examination findings presented separately as lists, graphs or summaries in the EPR view associated with the current patient
Includes Activating any interface with examination findings data. Changing the view or navigate into an already initiated view of examination findings data. Examination findings data presented as list of values, graphs, tables, images, scanned documents, headings, detailed views or as summary views. Examination findings grouped chronologically or based on types. Looking at examination findings presented in sub windows or pop-up windows. Time taken to navigate amongst examination findings and other activities related to manipulation of the examination finding view including sorting, filtering and querying actions. Verbal or non verbal interactions occurred during the examination findings reviewing if no gap in computer use (see definition for D) is evident. Reviewing examination findings related to blood pressure, height, weight, BMI, X-ray and ECG. All examination findings related to the current patient regardless of the type of the health care professional (HCP) involved or the source of the origin.
Excludes Reviewing lists of ungrouped examination results if shown within the encounter list view. Interruptions (see definition 27). Any break in computer use (see definition for D) ,
Start The first interaction with the keyboard or mouse to move the input focus from the current location, to any view with grouped examination findings data. For keyboard based interactions this is marked by the pressing of the relevant 'function key' or 'short cut key/s' or the first use of the 'cursor arrow keys' to move away from the current input focus with the aim of obtaining the grouped examination findings data. For mouse based interactions this is marked by the first visible movement of the mouse pointer, away from the last input focus to interact with the relevant 'icon', 'menu item', 'text link' or 'tab'.
End If the reviewing of examination findings is ended with a break in the computer use, this is marked by the instance the clinician stops looking at the screen. If the reviewing of examination findings is ended by moving away from the encounter list view, this is marked by the complete disappearance of the encounter list.
7. Free text entry
An uninterrupted sequence of free text data entry.
Includes Activating or initiating the free text data entry functionality or moving into the free text data entry area. Natural pauses of free text data entry interactions if no gap in computer use (see definition for D) is evident. Pasting-in the free text data copied from another area of the EPR, from an external application or document. Free text data entry done in the 'Prescribing/Therapy/Medication' sections of the EPR under 'Comment' or 'Note' sections. Free text data entry done linked to a coded data entry. Time taken to correct any errors associated with the free text data entry. Time taken to respond to any prompts associated with the free text data entry. Verbal or non verbal interactions occurred during the free text data entry interactions if no gap in computer use (see definition for D) related to free text data entry is evident. Free text data entry done into a structured data entry form/template. System delays, if the free text data entry attempt is not abandoned. Time taken for adding/saving/submitting/committing the free text data entry into the EPR
Excludes Writing letters including referral letters. Entering free text data into any other external application. Entering free text data into sections of the EPR other than those related to the current patient. Data entry done in the 'Dosage' field of the prescribing interface. Interruptions (see definition 27)

Any break in computer use (see definition for D) .

Start
The first interaction with the keyboard or mouse to move the input focus away from the current location, to initiate the free text data entry function.
For keyboard based interactions this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or the first use of the 'cursor arrow keys' to move away from the current input focus with the aim of initiating the free text data entry function.
For mouse based interactions this is marked by the first visible movement of the mouse pointer, away from the current input focus to interact with the relevant 'icon', 'menu item', 'text link' or 'tab'.

End
If the free text data entry interaction is ended by a gap in the computer use, this is marked by the instance the clinician stops interacting with the keyboard.
If the coded data entry is done into a text field in a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the instance the input focus is moved away from the text field.

8. Writing referral or other letters by the clinician

Clinician writing or dictating letters related to the current patient.

Includes
Activating or initiating applications or other letter writing facilities.
Using applications internal or external to the EPR to write the letter.
Typing a complete letter, filling a partially completed letter or letter template, pasting-in text copied from the EPR and text formatting tasks.
Dictating a letter to a Dictaphone or voice recorder application linked to the EPR.
Saving and printing the letter.
Verbal or non verbal interactions occurred during the letter writing interactions if no gap in computer use (see definition for D) is evident.
Writing letters in the free text data entry text fields of the EPR.
Time taken to load any letter templates.
Writing letters related to referral activities or addressed to other agencies linked to the current patient.
Interacting with the EPR to review or copy details needed to write the letter.

Excludes
Referral requests done using EPR system's referral functions or by filling structured forms.
Interacting with the EPR for tasks not related to the letter writing process.
Interruptions (see definition 27)
Any break in computer use (see definition for D) .

Start
If the letter is written within the current EPR interface, using an external word processing application, a separate EPR interface or by loading a letter template, the interaction start is marked by the first interaction with the keyboard or mouse to move the input focus from the current location, to initiate the letter writing process.
If the letter is recorded to a Dictaphone, this is marked by the point clinician starts dictating.
If the letter is dictated to a voice recording software available in the EPR system, this is marked by the first interaction with the keyboard or mouse to move the input focus away from the current location, to activate the recording software.

End
Disappearance of the interface used for writing or dictating the letter after closing it.
If the letter is written into a text field of the EPR, this is marked by the 'input focus' moving away from the newly entered text related to the letter.
If the Dictaphone is used for recording the referral letter, this is marked by the point the dictation process is completed and the Dictaphone is kept aside.

9. Reviewing letters attached to the patient's EPR

Clinician reading and reviewing the letters attached to the current patient's EPR.

Includes
Activating or initiating applications that display the electronic or scanned letters attached to the patient's EPR.
Using applications internal or external to the EPR to open, display and read the attached letters.
If an external application is used to open the letters, the time taken to initiate and load such application.
Navigating between multiple letters and within the opened letter.
Time spent on sorting, searching, filtering or grouping letters.
Verbal or non verbal interactions occurred during the letter reviewing interactions if no gap in computer use (see definition for D) is evident.
System delays, if the letter reviewing attempt is not abandoned.
Time taken to close or move away from the letter reviewing interface.
Letters received from hospitals or other entities related to the current patient, from other health care professionals who have seen the patient.
Reviewing letters of which the text is pasted into the medical record content.

Excludes
Reviewing the paper letters not digitized into the EPR.
Letters with test results if they only have set of values.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .

Start
If the letter is reviewed through an external document viewer application or a separate EPR interface this is marked by the first interaction with the keyboard or mouse to move the input focus from the current location, in order to launch the letter reviewing process.
If the letter is presented as an internal text filed within the patient's EPR, this is marked by the moment the input focus is moved away from the current location towards a such text area.

End
If the letter is reviewed through an external document viewer application or a separate EPR interface, this is marked by the disappearance of such an interface used for reviewing letters after closing it.
If the letter is presented as an internal text filed within the patient's EPR, this is marked by the moment the input focus is moved away from the text area.

10. Incomplete computer use

Any incomplete or purposeless interaction clinician performs using the computer system.

Includes
Purposeless use of the interface features of the EPR system or any other application.
Computer interactions that are performed incorrectly, resulting in adding no data into the EPR.
Tasks that are not completed as a result of interruptions, errors, change of objectives, or lost of their significance to the consultation.
Interactions with the computer system's peripheral devices in an aimless manner – dithering use of keyboard, mouse.
Clinician following the correct steps to perform a particular task with the computer system, but failing to achieve the expected end result due to system delay, error or insufficient data.
Discontinuing a particular interaction to initiate a different one.

Excludes
Duration of the system delay.
Tasks with multiple segments, but successfully completed.
Computer interactions triggered by the system itself without being initiated by the clinician.
Examinations (see definition).
Interruptions (see definition 27).
Doctor not in room (see definition).

Start
The first interaction with the keyboard or mouse to move the input focus away from the current location of the EPR system.
For keyboard based interactions this is marked by the pressing of the relevant 'function key/s' or the 'short cut key/s' or the 'cursor arrow keys' to change the current input focus.
For mouse based interactions where the interaction is initiated using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer, away from the current input focus.

End
The interaction end is marked by the point at which the current set of interaction is discontinued and another one is initiated or the resumption of verbal, non-verbal interactions with the patient.

11. Other paper work

Clinician engaging in paperwork that do not come under any other episodic interaction type, as part of the current consultation tasks.

Includes
Filling of printed forms related to the current consultation, supplied or printed off by the clinician or brought in by the patient.
Making notes on paper for the benefit of the patient or the clinician.
Issuing of 'Sick notes', 'Maternity certificates' and other types of certifications.
Filling in questionnaire forms.
Reviewing of printed letters, examination results or any other documentation related to the current consultation.
Using the computer (see definition) to obtain information needed to fill in the form.
Authorizing the documents – signing, stamping.
Verbal, non-verbal interactions between the clinician and the patient related to the document.
Reading or writing aloud interactions (see definition).

Excludes
Reviewing any documents in electronic format.
Paperwork related to the research projects the surgery or the clinician is taking part in.
Interruptions (see definition 27).

Start
The instance at which the clinician breaks away from the current interaction in order to locate the paper document before initiating the interactions using it.

End
The instance at which the clinician sets aside or handovers the paper document to the patient after completing the interactions using it.

12. Responding or reviewing prompts

Clinician looking at and responding to prompts presented by the EPR system.

Includes
Prompts associated with errors, warnings, alerts, reminders with or without input fields.
Looking at the prompt, reading its content.
Interacting with the form elements of the prompt interface – drop down lists, check boxes, radio buttons, text fields, buttons etc.
Navigation within the prompt interface.
Responding to prompt by entering data, interacting with input fields or by closing it.
Time taken for the disappearance of the prompt after the last interaction with it.
Closing, canceling, hiding, minimizing or acknowledging the prompt.
The duration the prompt is visible in the computer screen and clinician looking at it.
Prompts presented by the EPR system or any external application when the clinician is interacting with them for tasks related to the current consultation.
Prompts that appear during transitioning actions (see definition).
Prompts presented as pop-up windows, inline text messages.
Prompts associated with prescribing, data entry, session management, computer system errors and delays.

Excludes
The duration the prompt is visible in the interface, without the clinician looking at the computer screen (see definition).
Prompts presented by applications not used for consultation related tasks.
Prompts those are visible for longer durations, across multiple functional areas of the EPR interface.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .
Interactions with the EPR, subsequent to the prompt display as a result of its content.

Start
If the clinician is looking at the screen the interaction start is marked by the appearance of the prompt on the computer screen.
If the clinician is not looking at the screen when the prompt appears, the interaction start is marked by the next time clinician looks at the screen.

End
The disappearance of the prompt from the computer screen following the clinician responding to it.

13. Patient in the consultation room

The duration patient is physically present in the consultation room.

Includes
Patient walking in, through the consultation room's door.
Clinician examining the patient within the camera views or away from cameras or behind the curtains.
Interruptions (see definition 27).
Durations of clinician not present in the room.
Durations when patient can not be seen through any of the camera views, nevertheless if proceeding and following interactions suggest the patient's presence in the room.
Patient walking out, through the consultation room's door.

Duration/s when the patient has left the room temporarily as part of the consultation task.
Observable verbal, non verbal interactions between the clinician and the patient if both are not visible in either of the camera views.

The first occasion when the patient's physical presence in the consultation room is noticeable from any of the camera views.

The last noticeable moment of patient leaving the consultation room towards the end of the consultation.

14. Reading or writing aloud

Clinician saying out loud the text being looked at in the EPR or written into the EPR associated with the current patient.

Includes
Observable verbal interactions not directed towards another person.
Reading aloud while looking at the computer screen (see definition).
Writing aloud during the computer use (see definition for D) .
Reading/writing aloud during screen sharing interactions (see definition).
Natural pauses in the speech.
Reading aloud free text entries, comments, letters, instructions, guidelines, text content of prompts etc.
Writing aloud during free text, comment or instructions entries and letter writing using the computer system.

Excludes
Direct verbal interactions with the patient or another person who is physically present or over the phone.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .
Durations when patient is not in the room (see definition).

During paper or dictation based interactions.
Clinician reading the values in test results, examination findings.

Start
Start of the first apparent verbal interaction related to a read or write aloud action.

End
End of the last apparent verbal interaction related to a read or write aloud action.

15. Referencing – using electronic or printed resources

Clinician using electronic or paper based information sources for referencing purposes related to the current consultation.

Includes
Referencing when patient is in the room or not in the room.
For electronic reference sources;
Activating any interfaces with reference information.
Changing the view or navigate into an already initiated view of reference data.
If an external application is used to open the reference materials, the time taken to initiate and load such application.
Use of reference sources directly linked to the EPR features, online content, search engines, guidelines and interactive sources.
Navigating between multiple information sources or within the chosen document.
Time spent on sorting, searching and filtering reference sources.
Reference sources with text, graphical or video contents.
Verbal or non verbal interactions occurred during the referencing interactions if no gap in computer use (see definition for D) is evident.
Reading aloud interactions (see definition).
For paper based reference sources;
Locating the reference source.
Searching for the particular reference materials/topic.
Reading the content, including reading aloud actions.
Verbal or non verbal interactions occurred during the referencing interactions either if they are related or no gap in the use of reference material (see definition) is evident.
Completing the referencing interaction and keeping aside the reference source.

Excludes
Interruptions (see definition 27).
Reading documents not related to the current consultation.
Incomplete, abandoned or unsuccessful referencing attempts.
For referencing based on electronic sources;
Any break in computer use (see definition for D) .
Reading the documents attached to the patients EPR, or related referrals.
For referencing based on paper sources;
Any verbal or non-verbal interactions not related to the objectives of the referencing.
Having/holding the reference material, but not using it.

Start
For referencing based on electronic sources;
The first interaction with the keyboard or mouse to move the input focus away from the current location, to find the reference source.
For keyboard based interactions this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or the first use of the 'cursor arrow keys' to move away from the current input focus with the aim of locating the reference source.
For mouse based interactions this is marked by the first visible movement of the mouse pointer, away from the current input focus to interact with the relevant 'icon', 'menu item', 'text link' or 'tab'.
For referencing based on paper sources;
The instance at which the clinician verbally or non-verbally declares the intention to use a paper document for referencing.
Clinician breaking away from the current interaction in order to locate the paper reference material.

End
For referencing based on electronic sources;
If the referencing activity is ended with a break in the computer use, this is marked by the instance the clinician stops looking at the screen.
If the referencing activity is ended by moving away or closing the reference source, this is marked by the disappearance of the reference material from the computer screen.
For referencing based on paper sources;
The instance clinician sets aside the reference material after completing the referencing the process.

16. Referral – electronic or paper based structured methods

Clinician making a referral request for the current patient using a facility linked to the EPR system or paper form based structured methods.

Includes For EPR linked structured referral requests; Activating or initiating the referral request functionality in the EPR system, including the 'Choose and Book' service. Navigating away from the current input focus. Interacting with the relevant 'icon', 'menu item', 'text link' or 'tab' to initiate the referral request generation. Selection of the referral request by name based searching, filtering, or by following 'wizard' type forms. Entering specific details for the referral request, patient data, selecting the health service provider, its location, date and time. Adding any coded data entry (see definition) related to referral request. Adding any free text data entry (see definition) related to referral request. Verbal or non verbal interactions occurred during the referral request generation, if no gap in computer use (see definition for D) is evident. Confirming the referral request – adding/saving/submitting Printing the referral request, authorizing – signing, stamping. Time taken to correct any errors associated with the referral request generation. Time taken to respond to any prompts associated with the referral request generation. For paper form based referral requests; Filling the referral request form. Using the computer (see definition) to obtain information needed to fill the form. Authorizing the referral request – signing, stamping. Verbal, non-verbal interactions between the clinician and the patient related to the referral request – selecting the service provider, location, date, time. Verbal, non-verbal interactions between the clinician and the patient without causing any gaps in the form filling task.
Excludes Interruptions (see definition 27). For EPR based referral request, any break in computer use (see definition for D) except the authorizing steps. For paper form based referral request, time taken to locate the forms.
Start For EPR linked structured referral requests; The first interaction with the keyboard or mouse to move the input focus from the current location, to initiate the referral request generation function. For keyboard based interactions where referral request generation is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or by the first use of the 'cursor arrow keys' to move away from the current input focus. For mouse based interactions where referral request generation is initiated using 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer, away from the last input focus. For paper form based referral requests; The instance at which the clinician breaks away from the current interactions in order to locate the referral request form before initiating the interactions related to the paper based referral request generation.
End For EPR linked structured referral requests; The first visual affirmation in the EPR interface indicating that the referral request is generated and recorded into the patient's EPR. If the referral request is generated using a separate interface presented in a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the disappearance of such window/form or the movement of the 'input focus' away from such interface after a successful data entry. For paper form based referral requests; The instance at which the clinician sets aside the referral request form or handovers the form to the patient, after completing the referral request generation.
17. Prescribing – acute
Adding new acute prescriptions to the current patient's EPR.
Includes Time taken to activate or initiate the acute prescribing functionality or to move into the acute prescribing area. Generic steps of acute prescribing; Activating the prescribing functionality. Typing in the drug name. Reviewing the list of matching drug names presented by the EPR system. Selecting and confirming the drug name. Selecting the preparation and other specific details of prescriptions. Adding/saving the prescription to the patient's EPR. Entering drug dose, form, strength, quantity, any additional instructions and selecting the prescribing type. Time taken to respond to any prompts associated with the acute prescribing including the drug interaction warnings, adverse reactions or suggestions for alternative drug names. Time taken to correct any errors associated with the acute prescribing data entry. Multiple items of medication done in a single acute prescribing activity, if they are performed without a break in computer use (see definition for D) . Moving from an acute prescription for one medication to another.

Time taken for medication issue if it's done using the same interface used for adding the acute prescription item.
Verbal or non verbal interactions occurred during the acute prescribing interactions if no gap in computer use (see definition for D) related to acute prescribing data entry is evident.
Acute prescriptions that were added but not issued.

Excludes
Time spent on reviewing past prescriptions.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .
Acute prescription entries that were not added/saved to the EPR.

Start
The first interaction with the keyboard or mouse to move the input focus from the current location, to initiate the acute prescribing function.
For keyboard based interactions where acute prescribing function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s'.
For keyboard based interactions where acute prescribing function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus.
For mouse based interactions where acute prescribing function is initiated using 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer, away from the last input focus.

End
The interaction end is marked by the first visual affirmation given by the data entry interface indicating that the newly done acute prescription is added to the EPR.
If the acute prescribing data entry is done into a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the disappearance of such window/form after a successful entry.

18. Prescribing – new repeat

Adding new repeat prescriptions to the current patient's EPR.

Includes
Time taken to activate or initiate the new repeat prescribing functionality or to move into the new repeat prescribing area.
Generic steps of new repeat prescribing;
Activating the prescribing functionality.
Typing in the drug name.
Reviewing the list of matching drug names presented by the EPR system.
Selecting and confirming the drug name.
Selecting the preparation and other specific details of prescriptions.
Defining the prescription as a 'repeat'.
Adding/saving the prescription to the patient's EPR.
Entering drug dose, form, strength, quantity, any additional instructions and selecting the prescribing type.
Time taken to respond to any prompts associated with the new repeat prescribing including the drug interaction warnings, adverse reactions or suggestions for alternative drug names.
Time taken to correct any errors associated with the new repeat prescribing data entry.
Multiple items of medication done in a single new repeat prescribing activity, if they are performed without a break in computer use (see definition for D) .
Moving from a new repeat prescription for one medication to another.
Time taken for medication issue, if it's done using the same interface used for adding the new repeat prescription item.
Verbal or non verbal interactions occurred during the new repeat prescribing interactions if no gap in computer use (see definition for D) related to new repeat prescribing data entry is evident.
New repeat prescriptions that were added but not issued.

Excludes
Time spent on reviewing past prescriptions.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .
Acute prescription entries that were not added/saved to the EPR.

Start
The first interaction with the keyboard or mouse to move the input focus from the current location, to initiate the new repeat prescribing function.
If the repeat prescribing function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s'.
For keyboard based interactions where acute prescribing function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus.
For mouse based interactions where new repeat prescribing function is initiated using 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer, away from the current input focus.

End
If the prescription is not immediately issued, this is marked by the first visual affirmation given by the data entry interface indicating that the newly done new repeat prescription is added to the EPR.
If the prescription is immediately issued, this is marked by the first visual affirmation given by the data entry

interface indicating that the newly done new repeat prescription is indicated as 'issued'.
If the new repeat prescribing data entry is done into a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the disappearance of such data entry window/form after a successful entry.

19. Prescribing – old repeat

Interacting with the EPR system for generating prescriptions based on previously added repeat prescription details stored in the patient's EPR.

Includes

Time taken to activate or initiate the repeat prescribing functionality or to move into the repeat prescribing area.
Selecting the medication/s from the repeat prescriptions list.
Responding to any prompts associated with the repeat prescribing.
Time taken to correct any errors associated with the repeat prescribing.
Multiple items of medications selected in a single repeat prescribing activity, if they are performed without a break in computer use (see definition for D) .
Time taken for medication issue, if it's done using the same interface used for adding the repeat prescription items.
Verbal or non verbal interactions occurred during the repeat prescribing interactions if no gap in computer use (see definition for D) related to the prescribing data entry is evident.
Repeat prescriptions that were activated but not issued.

Excludes

Reviewing past prescriptions.
Time spent on reviewing the list of repeat prescriptions without re-activating any.
Interruptions (see definition 27)
Any break in computer use (see definition for D) .
Acute prescription entries that were not added/saved to the EPR.

Start

The first interaction with the keyboard or mouse to move the input focus from the current location into the repeat medication list, to initiate the repeat prescribing function.
For keyboard based interactions where the repeat prescribing function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' to move into the repeat medication list.
For keyboard based interactions where repeat prescribing function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus to move into the repeat medication list.
For mouse based interactions where repeat prescribing function is initiated using 'point and click selections', 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer into the repeat medication list, away from the last input focus.

End

If the prescription is not immediately issued, this is marked by the first visual affirmation given by the data entry interface indicating that the selected repeat medication is added to the current prescription list for issuing.
If the prescription is immediately issued, this is marked by the first visual affirmation given by the data entry interface indicating that the selected repeat medication is marked as issued.
If the repeat prescribing data entry is done into a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the disappearance of such data entry window/form after a successful entry.

20. Reviewing of prescriptions

Reviewing and interacting with the list of medications stored in the current patient's EPR.

Includes

Time taken to activate any interface with list of past or current prescriptions data.
Time taken to change the view or navigate into an already initiated view of prescriptions list.
Past or current prescriptions presented as list of values, as detailed views or as summary views.
Time taken to navigate amongst the prescriptions list and other activities related to manipulation of the list view including sorting, filtering and querying actions.
Verbal or non verbal interactions occurred during the prescriptions list reviewing if no gap in computer use (see definition for D) is evident.
Selection of any items from the prescriptions list and making any changes to them including modifying, placing them into different categories, canceling or adding notes.

Excludes

Reviewing lists of ungrouped prescriptions if they are shown within the encounter list view.
Prescription reviews done during issuing and printing of prescriptions.
Interruptions (see definition 27).
Any break in computer use (see definition for D) .

Start

The first interaction with the keyboard or mouse to move the input focus from the current location, to a view a list of past or current prescriptions.
For keyboard based interactions where prescription review function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s'.
For keyboard based interactions where prescription review function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus.
For mouse based interactions where prescription review is initiated using 'text links', 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer, away from the last

input focus.
End If the prescription reviewing is ended by moving away from the prescription list view, this is marked by the disappearance of the encounter list. If the prescription reviewing is ended with a break in the computer use, this is marked by the instance the clinician stops looking at the screen.
21. Issuing and printing prescriptions
Issuing the prescriptions added to the current patient's EPR and sending the prescription details to the printer.
Includes Activating the interface/view with the list of medications prescribed during the current consultation. Total time spent on issuing and printing the prescription, regardless of carrying them out as a single step or two separate steps. Time taken to change the view or navigate into an already initiated view with list of prescriptions created but not issued. Responding to any prompts associated with the prescription issuing and printing. Issues and printing multiple items of medications in a single block of interactions, if they are performed without a break in computer use (see definition for D) . Verbal or non verbal interactions occurred during the interactions if no gap in computer use (see definition for D) related to prescription issuing and printing is evident.
Excludes Reviewing lists of current prescriptions, without initiating the issuing process. Prescription issuing done as part of the prescribing task. Collecting the printed prescription, dealing with the problems with printing. Interruptions (see definition 27). Any break in computer use (see definition for D) .
Start The first interaction with the keyboard or mouse to move the input focus from the current location, to initiate the prescription issuing and/or printing function. For keyboard based interactions where prescription issuing and/or printing function is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s'. For keyboard based interactions where prescription issuing and/or printing function is initiated by selecting a 'text link', this is marked by the first use of the 'cursor arrow keys' to move away from the current input focus. For mouse based interactions where acute prescribing function is initiated using 'menu items', 'icons' or 'right-click option list', this is marked by the first visible movement of the mouse pointer, away from the last input focus.
End The interaction end is marked by the first visual affirmation given by the EPR interface for completing the prescription printing task. If the tasks completion is shown by a prompt this is marked by the appearance of the prompt. If the tasks completion is indicated by the disappearance of the prescription issue/print interface, this is marked by its disappearance.
22. Sharing the screen with the patient
Both the clinician and the patient sharing the information presented in the EPR system together and interacting based on that information.
Includes Patient moving towards the screen from the normal seating position. Clinician changing the position or direction of the computer screen. Verbal, non verbal interactions related to clinician inviting the patient or patient requesting to view the information on the screen. Time taken to interact with the computer system to achieve the view clinician or patient wanted to share. The duration between the screen sharing request and termination, provided that both the patient and clinician could view the screen content without any physical restrictions. Verbal, non verbal interactions between the patient and clinician, their interactions with the computer system between the screen sharing request and termination.
Excludes Interruptions (see definition 27). Physical examination activities (see definition 5). Patient looking at the screen while clinician's computer use. Reading or writing aloud actions (see definition) by clinicians without any other screen sharing interactions.
Start The instance at which the clinician verbally or non-verbally invites the patient to look at the computer screen. Clinician facilitating the screen sharing by adjusting the computer screen to enable the patient to have a clear view of it or by pointing towards the particular section of the interface.

End The instance clinician verbally or non-verbally declares that the screen sharing is finished. Clinician re-adjusting the computer screen, away from the patient's views. The moment the clinician resumes verbal interactions without directly referring to the screen content, or resumes computer use interactions while the patient is not looking at the screen.
23. System delays or errors
Time spent by the clinician while using the EPR system for responding to errors or system delays.
Includes System delays and errors related to all clinician-EPR interactions. Delays in loading or closing the EPR system or external applications. Unresponsive interfaces or functionalities. Errors with data presentation – incomplete, missing, wrong data. Time taken to review and respond to error messages. Mouse pointer turning to the 'hour glass' symbol to represent background processing – 'system busy' status. Delays due to issues with computer system's peripheral devices – printer, monitor, key board, mouse. Restarting the computer system or only the EPR system.
Excludes Delays or errors outside the clinician's computer use time (see definition for D). Data entry errors. Delays due to human actions.
Start The start point of the unexpected break in the computer use (see definition for D) caused by the system delay or error. For a system error with an associated error message, this is indicated by the appearance of that error prompt on the screen and the instance the clinician notices it. For a system delay which is indicated by a change of the mouse pointer symbol this is marked by the moment it changes. If the system becomes un-responsive, this is marked by the first instance that the clinician notices that the system is not responding, as indicated by any observable interaction.
End The instance at which the clinician's computer use or the verbal, non-verbal interactions related to the consultation resumed, after the system becomes responsive or responding to the error.
24. Use of data entry forms
Interacting with the structured data entry forms.
Includes Time taken to activate or initiate the data entry forms. Free text data entry, coded data entry and interactions with other user interface elements within the form- check boxes, radio buttons, drop down lists. Time taken to correct any errors associated with the use of data entry forms. Time taken to respond to any prompts associated with the free text data entry. Verbal or non verbal interactions occurred during the use of data entry forms if no gap in computer use (see definition for D) is evident. System delays, if the use of data entry form attempt is not abandoned. Time taken for adding/saving/submitting/committing the data entered into the data form into the EPR. Used of data entry forms without adding any new data, only for preview purposes. Use of data entry forms offered by the EPR system, without the clinician activating them purposely.
Excludes Blood pressure data entry form. Interruptions (see definition 27). Any break in computer use (see definition for D) . Form based data entries that were not added/saved/committed to the EPR. Data entry forms presented by external applications.
Start The first interaction with the keyboard or mouse to move the input focus from the current location, to activate the structured data entry form. For keyboard based interactions where structured data entry form is activated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or by the first use of the 'cursor arrow keys' to move away from the current input focus to select the 'text link' for activating the structured data entry form. For mouse based interactions where structured data entry form is activated using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer, away from the last input focus.
End The disappearance of the structured data entry form or the movement of the 'input focus' away from such interface after completing the interactions with it.
25. Reviewing of test results
Reviewing test results presented separately as lists, graphs or summaries in the EPR view associated with the current patient.

Includes Activating any interfaces with test results data. Time taken to change the view or navigate into an already initiated view of test results data. Test results data presented as list of values, graphs, tables, images, scanned documents, headings, detailed views or as summary views. Test results grouped chronologically or based on types. Looking at test results presented in sub windows or pop-up windows. Time taken to navigate between test results and other activities related to manipulation of the test results view including sorting, filtering and querying actions. Verbal or non verbal interactions occurred during the test results reviewing if no gap in computer use (see definition for D) is evident. All test results related to the current patient regardless of the type of the health care professional (HCP) involved or the source.
Excludes Reviewing lists of ungrouped test results if shown within the encounter list view. Interruptions (see definition 27). Any break in computer use (see definition for D) .
Start The first interaction with the keyboard or mouse to move the input focus away from the current location, to any view with grouped test results data. For the keyboard based interactions, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or the first use of the 'cursor arrow keys' to move away from the current input focus with the aim of obtaining the grouped test results data. For mouse based interactions this is marked by the first visible movement of the mouse pointer, away from the last input focus to interact with the relevant 'icon', 'menu item', 'text link' or 'tab'.
End If the reviewing of test results is ended with a break in the computer use, this is marked by the instance the clinician stops looking at the screen. If the reviewing of test results is ended by moving away from the encounter list view, this is marked by the disappearance of the test results list.
26. Generating test requests – using electronic or paper based methods
Generating a test request using the EPR system, other EPR linked software application or by completing a printed test request form.
Includes For EPR based test requests; Activating or initiating the text request functionality in the EPR system. Navigating away from the current input focus. Interacting with the relevant 'icon', 'menu item', 'text link' or 'tab' to initiate the test request generation. Selection of test request by name based searching, filtering or by following 'wizard' type forms. Entering specific details for test requests, patient data. Adding any coded data entry (see definition 2) related to test request. Adding any free text data entry (see definition 7) related to test request. Verbal or non verbal interactions occurred during the test request generation, if no gap in computer use (see definition for D) is evident. Confirming the test request – adding/saving/submitting Printing the test request, authorizing – signing, stamping. Time taken to correct any errors associated with the test request generation. Time taken to respond to any prompts associated with the test request generation. For paper based test requests; Filling the test request form. Using the computer system (see definition for D) to obtain information needed to fill the form. Authorizing the test request – signing, stamping. Verbal, non-verbal interactions between the clinician and the patient related to the test request. Verbal, non-verbal interactions between the clinician and the patient that do not cause any gaps in the form filling task.
Excludes Interruptions (see definition 27). For EPR based test request, any break in computer use (see definition for D) except the authorizing steps. For paper form based test request, time taken to locate the forms.
Start For EPR based test requests; The first interaction with the keyboard or mouse to move the input focus away from the current location, to initiate the test request generation function. For keyboard based interactions where test request generation is initiated using keyboard commands, this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or by the first use of the 'cursor arrow keys' to move away from the current input focus. For mouse based interactions where test request generation is initiated using 'menu items', 'icons' or 'right-click

option lists', this is marked by the first visible movement of the mouse pointer, away from the last input focus. For paper based test requests; The instance clinician breaks away from the current interactions in order to locate the test request form before initiating the interactions related to the paper based test request generation.
End For EPR based test requests; The first visual affirmation in the EPR interface indicating that the test request is generated and recorded into the patient's EPR. If the test request is generated using a separate interface presented in a 'pop-up window' or 'sub window' or data entry form interface, this is marked by the disappearance of such window/form or the movement of the 'input focus' away from such interface after a successful data entry. For paper based test requests; The instance clinician sets aside the test request form or handovers the form to the patient, after completing the test request generation.
27. Third party interruptions
Duration of observable third party interruptions that occurred during the consultation.
Includes Incoming phone calls answered by the clinician, including those to the clinician's mobile phone. Staff members or colleagues walking into the consultation room with or without clinician's acknowledgement. Interacting with external applications for tasks not related to the current consultation, causing distraction to the current consultation tasks. Clinician interacting with the EPR system performing tasks related to the EPR of another patient which has no connection to the current consultation, causing distraction to the current consultation tasks. Making technical adjustments to the computer system. Technical errors associated with the EPR system. Computer system failures. Outgoing phone calls from the clinician, related or un-related to the consultation. Dealing with documents, tasks not directly related to the consultation or patient, including interactions related to the research projects the surgery or doctor is taking part.
Excludes Interruptions occurred when the clinician is not in the room. Patient or clinician preparing for the examination process. Observable interruptions that do not cause any interference with the clinician's computer use or verbal or non-verbal interactions between the clinician and patient.
Start The start of the observable break in the clinician's computer use or verbal, non-verbal interaction between the clinician and the patient related to the consultation as a result of the interruption.
End The instance at which the clinician's computer use or the verbal, non-verbal interactions related to the consultation resumed, after the conclusion of the interruption.
28. Transitions between EPR system's functional areas
Time spent by the clinician while using the EPR system, to move from one functional area or feature of the EPR system interface to another.
Includes Generic steps of intra-EPR transition include; Moving away from the current functional area. Navigating into the new functional area. Locating the elements to initiate the new functional area. Interacting with the EPR interface elements to activate/obtain a usable view of the new functional area. Obtain the new functional area and using its features. Moving away from the current functional area in the EPR interface. Moving into the new functional area of the interface. Navigation interactions with the EPR interface. Interacting with 'menu items', 'icons', tabs, 'form elements', lists, 'sub windows', 'pop-up windows'. Reviewing and responding to prompts. Grouping, sorting, searching and filtering actions in order to obtain the usable view of the next functional area. Interactions with the keyboard, mouse or computer screen. Verbal or non verbal interactions occurred during the transition interactions if no gap in computer use (see definition for D) related to transitioning action is evident. Changes in the EPR interface related to the transition, regardless of the clinician looking at the screen (see definition) or not. System delays (see definition). Moving the mouse pointer or keyboard focus directly or indirectly towards the target functional area. Duration when the system appears as busy – mouse pointer turning to 'hour glass' symbol.

Excludes Interacting with external applications or computer system features external to the EPR system. In-completed, abandoned or unsuccessful interactions for transitioning. Interruptions (see definition 27) Any break in computer use (see definition for D) .
Start The first interaction with the keyboard or mouse to move the input focus away from the current location, to go into a different functional area of the EPR system. For keyboard based interactions this is marked by the pressing of the relevant 'function key' or the 'short cut key/s' or the 'cursor arrow keys' to change the current input focus. For mouse based interactions where the transition is initiated using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer away from the current input focus.
End The interaction end is marked by the first visual affirmation given by the EPR interface indicating that the transition is completed and the new functional area is ready to use. If the origin of the transition is from a 'pop-up window' or 'sub window' or 'data entry form' interface, this is marked by the complete disappearance of such data entry window/form and the input focus moving into the new interface or the specific location in the new functional area. If the origin of the transition is from a specific area of the EPR interface to another functional area, this is marked by the input focus successfully moving into the new interface or the specific location in the new functional area.
29. Transitions between EPR system and external applications
Time spent by the clinician moving between the EPR system and other external software applications related to perform consultation tasks related to the current patient.
Includes Generic steps of inter application transition include; Leaving the current functional area of the source application. Launching/switching into the external destination application. Navigating into/locating the elements to initiate interactions with the functional area of the destination application. Interacting with the destination application's interface elements to activate/obtain a usable view of the new functional area. Obtaining the new functional area and using its features. Moving away from the current application and moving into the external application. Navigation interactions within the source and destination application interfaces. Interacting with 'menu items', icons, tabs, form elements, lists, sub windows, pop-up windows. Reviewing and responding to prompts. Grouping, sorting, searching and filtering actions in order to obtain the usable view of the new functional area. Interactions with the keyboard, mouse or computer screen. Verbal or non verbal interactions occurred during the transition interactions if no gap in computer use (see definition for D) related to transitioning action is evident. Changes in the EPR interface related to the transition, regardless of the clinician looking at the screen (see definition) or not. System delays (see definition). Moving the mouse pointer or keyboard focus directly or indirectly towards the target functional area. Duration when the system appears as busy – mouse pointer turning to 'hour glass' symbol.
Excludes Interacting with functional features within the same application. Incomplete, abandoned or unsuccessful interactions for transitioning. Interruptions (see definition 27). Any break in computer use (see definition for D) . Transitions between applications not related to the current consultation.
Start The first interaction with the keyboard or mouse to move the input focus away from the current location of the EPR system, to go into a functional area of an external application. For keyboard based interactions this is marked by the pressing of the relevant 'function key/s' or the 'short cut key/s' or the 'cursor arrow keys' to change the current input focus. For mouse based interactions where the transition is initiated using 'menu items', 'icons' or 'right-click option lists', this is marked by the first visible movement of the mouse pointer, away from the current input focus.
End The interaction end is marked by the first visual affirmation given by the EPR or the external application's interface indicating that the transition is completed and the new application and its functional area is ready to use. This may also be indicated by the appearance of the application's interface and the input focus successfully moving into a specific location in the new functional area.
30. Other interactions
Any type of interaction with a significant influence to the consultation process that does not come under any other episodic interaction type.

Includes Interactions between the patient and the clinician, patient and the computer or clinician and the computer. Interactions with third parties. Clinician using EPR system or any other external application for interactions that do not come under other defined categories. Unsuccessful, incorrect or abandoned interactions. Verbal or non-verbal interactions. Use of the EPR system or other application for tasks not related to the consultation. Clinician using the phone to invite the patient in or to make outgoing calls related to the consultation. Use of the online resources or tools. Use of the printer. System delays, errors related to external applications. Clinician inviting colleagues into the consultation to assist – getting second opinion. Time taken to prepare for tasks. House keeping tasks.
Excludes Interactions which are not directly or indirectly observable from the audio-visual recording.
Start The start point of the observable aspect of the particular interaction
End The end point of the observable aspect of the particular interaction.

Appendix C – EPR interface design characteristics and their implications

	Influence on task initiation	**Influence on task completion**	**Influence on integrating into workflow**	**Contextual modifiers**	**Relationship with Dr-Pt verbal/non-verbal**	**Implications for system design**
Past encounter reviewing	**Positively** Having a summary view in default view *(fastest),pcs* Providing summary as a prompt when loading MR, *pcs* Encounter page in a tabbed window, *vis'* Encounters organised by problems, *syn'* **Negatively** Separate page linked to default view, *LV* Summary results are not embedded, need to find seperately, *LV* 'current' tab is the default, but clinicians find 'journal more useful, used for initiation	**Positively** Default view with encounter summary - *pcs* Encounter summary in a sub window in default view, less navigation - *vis'* Data entry done in pop-up windows, encounter summary in back ground - *syn'* Encounters linked to problems - *Syn'* scrolling with page up/down - *LV* **Negatively** Having to move between separate pages - *LV* Encounters are grouped by dates only, no explicit problem linkage - *vis'* Difficult to move from summary to detail history - *pcs* Letters, results embedded using item numbers, need separate navigation for details - *LV* Need point and click before scrolling, less control with keys	Having encounter details in separate, difficult to access pages influences encounter reviewing to be done less frequently, for longer durations Presentation of encounter summary in default view or fast navigation between default and encounter views result in more number of encounter reviewing episodes Clinicians respond to reminders when presented during encounter reviewing Presentation of test results and medication are useful, minimise need for visiting pages dedicated for those topics Facilities for grouping by problems, chronologically are useful	GP style may determines the occurrence: not reviewing as a practice/ calling-in after finish reviewing/using the time available after calling in (not if meet and invite method used) Type of problem, availability to of letters/test results may influence the duration Room layout influences if clinician attempts to review details with patient within core consultation	Often overlapped with verbal interactions, when done within core Clinician may decide to read-aloud to remind patients on past entries, uses mostly free-text in such situations Chronologically ordered, problem oriented views assist Dr-Pt talk	Encounter summary should be present in the default view Encounter details should be readily accessible and shareable despite user's current location within the EPR system There should be a direct path to move between detailed and summary view of encounters Should support both problem oriented and chronological ordering of encounter information, with facilities to filter if needed Users should be able to customise the content of the patient summary prompt, and enable/disable based on preference and to define rules about their presentation Keyboard based navigation should be available within list views Viewing areas should be uncluttered, optimally partitioned and easily navigable. Complex navigation structures (navigation trees, multiple selections) and inconsistent activation options should be avoided
Test results review	**Positively** Test summary available within encounter with features for filtering	**Positively** Each results set separately viewable - *LV, PCS*	Summary view within encounter details minimise the need for leaving default view Complex navigation	May result in triadic episodes/screen sharing when explaining the results r if inquired by the patient	when done within core often overlaps with verbal interactions, Screen shared	

	(fastest),S Separate page accessible via character keys ,*LV* Icon in default view, *vis'* separate page with a visible tab, *vis'* **Negatively** As an element of an expandable tree structure, *vis'* separate results page, search for test type, *LV*	Can filter within encounter view – *syn'* **Negatively** Available mainly as embedded within encounter details -*syn'* Need to select linked problem first- *syn'* Need to click on child elements in 'tree view' to change results view - *vis'*	structures are demanding for selecting test types and dates		when explaining high-low values	Presentation of test or examination results, letters from other HCPs should be contextualised by the latest associated encounter summary or should provide facilities for simultaneous viewing
BP data entry	**Positively** icon in default view *(fastest), syn'* Auto suggestion for 'BP' text entry selecting from main menu, *vis'* right click on existing entry, *vis'* use common coded entry input, *vis', syn'* **Negatively** BP entry in common template, navigate between pages, *LV* auto suggestion resulting in a picking list	**Positively** sys over dias presentation - *syn'* Entering Sys' moves focus to dias' input - *LV* Data items with default values - *syn'* **Negatively** Horizontal positioning of sys', dias' inputs - *syn'* Need to point and click before entering - *pcs, vis', syn'* Non-specific free text area - *Syn'* Previous and average recording data - *pcs* Offering a picking list when 'auto suggesting' - *pcs* Part of a complex template Templates taking longer to load	Ordering of data input sequence can reduce the navigation demands Additional background details are useful for Dr-Pt interactions, reduces need for visiting historical data Non specific input areas might collect un-related/inconsistent data BP recording is best placed as a separate form rather than within complex templates/provide linking Having additional coding might improve coding, but problematic when associated with guidelines	GP style influence the recording of additional data/leaving the default values or making comments	If past values/average values are presented, often referred by GPs to comment on.	**CODED & BP** Auto suggestion techniques should be 'context aware' - based on previous recordings, current problem title, active problems, and consultation heading being used. Global and dynamic rule sets to validate code presentation and selection, i.e. avoid situations like offering 'never smoked' as a code when patient has already been coded as a smoker! Features to support 'selective' problem orientation, with capacity to customise its activation based on consultation heading, problem type or consultation type. Enforce validation rules for examination results entry, facilities for basic error
Coded data entry	**Positively** Auto suggestion based on	**Positively** Auto suggestion' with	small sub-window for data entry allows to have the	GP's computer use style may influence to have	Rarely interacts with patient during	

	text entry or previously used codes *(fastest)*, *pcs* Activating using a function key, *LV* Semantic auto completion approach - code suggestion as text typed in icon for 'add medical history' (v,s) facility to copy previous codes, *pcs* icons for common codes **Negatively** Selection of encounter and problem are pre-conditions, *syn'* Select from main menu, *vis'* **Negatively**	limited number of items - *pcs* Direct entry of Read Code Correct use of search term, awareness, e.g. Smoking cessation **Negatively** If the desired item not in the initial view, need to switch to the extended list view - *vis', pcs, syn'* Picking list too long, multiple pages Code selection using assigned character keys - *LV* Having to redo code search by re-wording Auto suggestion may force re-wording, effort to cancel Adding codes under structured headings *pcs, LV*	contextual data in the background (V) Problem oriented approaches increases number of codes entered When searched, offered the matching code alone, without associated picking list. GP assume what provided as the best. having 'add history' icon doesn't support episodic nature number of items visible in a picking list should not be fixed, - 'context aware' selection Clinicians prefer re-wording the search than scrolling through	conversational coding or block coding	code selection	corrections, and selection of unit Data entry forms to have smaller number of input areas where possible, with features to support both flexible movement patterns and ability to enforce desirable movement paths. Problem codes should be linked with reference materials/images/knowledge based articles for easy sharing with patients Systems to be aware of search term re-wording attempts and to automatically suggest comparable terms or offer extended picking lists without requiring extra manual navigation Picking lists to behave as 'weighted list' based on code popularity, associated data quality issues and the content of the current view, with possibility of switching to a 'tag/word cloud' view to recognise the inter-relationship between codes Availability of icons for commonly used coded and examination results entries, however optimising the number of visible icons to avoid any additional time needed to navigate/select them or to recognise the purposes.
Free text entry	**Positively** Free text and coded into same input area, easy to move between *(fastest)*, *pcs* No direct transitions available, always from coded to free text entry - *syn', vis'* Need to point and click to switch from coded to free text - *vis', syn'* Submitting coded item takes to free text by default, *LV*	**Positively** Easy movement between consultation headings - Point and enter instead of select from text links **Negatively** Interference from 'auto-suggestion' Default view gives less prominence to free text input area - *Syn', Vis'* need to link with a coded item, no direct entry possible - *vis', syn'* Selection of appropriate	Coded-free text association within adjacent text input areas provides faster transitions from coded to free text Code-free text linkage may force GPs to be block users Coded-free text integration provide faster transitioning both ways around How they are offered in summary view have an influence on free text	GP style and nature of the problem influences the amount of free text entry/ efforts on correcting sentence errors	Often adopts conversational use if done within core consultation	

	Negatively selection of 'header' using text links before entering free text - *LV*	'heading' Difficult to enter encounter if more than one problem Point and click' to submit an entry instead of 'enter' No mechanisms to introduce line breaks, re-selecting the same heading - *LV*	entering			**FREE TEXT** Free text entry and coded entry input should be integrated to facilitate swift transferring between two entry modes. Structured free text entry areas linkable not only to problems, but also to reference materials, guidelines, care pathways etc. Facilities to directly annotate and link test/examination results **BOTH CODED & FREE TEXT** Facilities to re-use and modify previous coded or free-text entries using 'drag and drop', point and click or menu based methods are too demanding. Ability to record frees text and coded items 'conversationally' and structure/organise them later in the consultation when the problem is established.
Medication list review	**Positively** Available in encounter view linked to problems *(fastest) - syn'* separate page accessible	**Positively** Problem linked presentation - *syn'* icons to move between current, acute, repeat,	presentation of current rx amongst other problem related data minimises the need for leaving default view	Influenced by consultation objectives/outcomes	Often verified with Pt, observed as overlapping verbal interactions Could be initiated	**TAKING ACTIONS - COMMON** Common and consistent patterns for common

	via tab-*syn'* separate page accessible via character key-*LV* available in encounter view, chronologically - *PCS* Tabbed sub-page for 'scripts' within, tabbed page for 'therapy' - *vis'* **Negatively** Function key to prescriptions page, then text link to list view - *pcs*	past - *vis', syn'* **Negatively** Text links or function keys to navigate between Rx types - *PCS* Tabbed sub windows within medication list - *Vis'* No facilities for filtering by problems difficult to scroll if too many items	Having to leave the default view causes overheads due to extra navigation between problems and prescriptions Default Rx list should provide all types of current scripts, with facilities to filter. Having separate lists for acute, repeats and current often causes additional navigation Large number of text links, with no clear separation between Rx list manipulation functions and those for Rx actions result in longer transitions between rx list types.		due to a comment from Pt	prescribing tasks Provide an overview of the current record to relate decisions to the consultation's progress Ability to switch to a sharable summary view to discuss 'next steps' with patients Default view to indicate an easily recognisable summary to support consultation closure - problem establishment, associated actions and plans for follow-up Dedicated function keys to support more keyboard driven tasks Customisable global views, interaction patterns and rule sets linkable with user's login details - different GPs have different styles
Acute prescribing	**Positively** Activated via character key in medications list view *(fastest) - LV* add drugs' text link within 'prescribing' view - *pcs* select from 'add' menu - *vis'* icon for 'add medication' - *vis'* **Negatively** Drug name typed into coded entry input area - *syn'*	**Positively** shows a single prompt covering important aspect - *LV* only the essential data items to fill in, enter activates next step - *LV* Same input area for repeat, marked using character key - *LV* Prompts showing within the main prescription interface - *Vis'* **Negatively** Providing prompts in two occasions - when adding drug, then saving Rx - *Vis'*	Ability to use navigation keys reduces time taken to review list items Large number of text links. function keys and inconsistency in their placement require longer navigation time Vertically arranged input areas in Rx add input area results in ordered entry of data with minimum delay Navigation between input areas requiring point and click adds a large proportion of navigation overheads	existing medications, allergies ay result in additional prompts	medication review prompts may initiate Dr-Pt talk The use of medication and next steps are often explained during Rx add.	**NEW Rx ENTRY** Prescribing data entry to have vertically ordered input areas to facilitate swift movement between inputs Single structured prompt for each medication, display only if concerns needing Dr's attention exist. Ability to do individual or multiple prescriptions at any point with immediate or

		Prompting to review the medication before each issuing Selections to be done using check boxes, character keys - *Vis', Syn'* Separate tabs for additional details within Rx window - *PCS* No specific order for filling in rx details - *vis', pcs, syn'* Need to link with problem - *pcs, syn'*	Combined presentation of prompts and warning is efficient			delayed issuing Current medication list presented in the default view with facilities to filter based on Rx type
Prescription issuing process	**Positively** function key in default view - *syn' (fastest), vis'* Activate through function keys available within medication page - *LV* Individual workflows by combining features - *PCS* **Negatively** select items and 'issue and print' in medication list - *pcs*	**Positively** Items can be marked for issuing by highlighting - *pcs* Items can be marked for issuing when adding - *syn', vis'* Direct issue of marked item from default view - *Vis'* Printing without pop-up messages - *LV, PCS* **Negatively** Need to specify using a check box - *syn', vis'* Printing message overtake default view, can not interact with other areas - *Vis'* Having two steps for marking and issuing	List based issue is efficient than two stage mark and issue approach Facilities should exist for both individual and block issuing, and to issue directly from default view Providing features to customise activation methods may offer less demanding integration	Room layout could influence the printed Rx collection and handing in process.	Issuing. Printing and Rx handing in often done in conversational manner.	

Appendix D – Summary of quantitative data

Guide: **X**=mean, **M**=Media, **SD**=Standard Deviation, **IQR**=difference between 2nd and 4th quartiles, **Ntot**=total count, **Ntot%**-as a percentage of total count, **t**=total duration in 10th of a second, **ttot%**=as a percentage of the total serration, **tpart%** = as a percentage of the total duration of the specific category

		X	SD	M	IQR	Min	Max	Ntot	Ntot%	t	ttot%
AI consultations		11:49	05:17	11:07	06:22	02:37	31:25	163	100.00	115540.89	100.00
EPR system											
	LV	11:11	05:18	09:55	06:44	02:55	24:39	57	34.97	38256.38	33.11
	PCS	13:25	06:08	12:29	05:29	03:15	31:25	36	22.09	28975.97	25.08
	Vision	12:16	04:45	11:42	04:56	03:59	28:03	40	24.54	29444.49	25.48
	Synergy	10:29	04:26	10:14	07:05	02:37	19:26	30	18.40	18864.05	16.33
Dr ID											
LV	**GP01**	11:16	05:28	09:52	06:52	03:41	22:10	17	10.43	11492.91	9.95
	GP06	09:12	04:02	08:45	06:22	05:05	14:11	4	2.45	2207.24	1.91
	GP10b	10:12	05:38	08:48	08:19	02:55	24:23	15	9.20	9181.89	7.95
	GP12	09:40	04:26	09:40	02:37	03:11	20:35	10	6.13	5801.96	5.02
	GP14	14:30	05:00	13:05	07:00	07:31	24:39	11	6.75	9572.38	8.28
PCS	**GP03**	17:05	07:10	15:07	09:40	08:48	31:25	14	8.59	14350.47	12.42
	GP10a	11:08	03:38	11:51	04:35	03:15	15:01	10	6.13	6680.74	5.78
	GP15	11:02	04:27	10:09	04:14	05:08	19:25	12	7.36	7944.76	6.88
Synergy	**GP04**	12:12	03:11	13:25	04:58	06:47	16:46	13	7.98	9522.33	8.24
	GP05	11:55	04:23	11:39	05:46	05:06	19:26	10	6.13	7153.88	6.19
	GP08	05:13	01:54	05:48	03:07	02:37	07:48	7	4.29	2187.84	1.89
Vision	**GP02**	12:15	03:21	12:22	04:28	07:34	18:03	7	4.29	5142.45	4.45
	GP07	11:21	02:49	11:32	04:08	07:25	15:17	6	3.68	4083.00	3.53
	GP09	11:26	02:50	11:32	04:00	07:29	16:09	8	4.91	5491.77	4.75
	GP11	14:24	07:45	11:35	09:06	07:44	28:03	8	4.91	6910.89	5.98
	GP13	11:51	04:58	12:08	08:42	03:59	18:30	11	6.75	7816.38	6.77

Table 9.1: Durations of the greater consultation in mm:ss

		Duration (mm:ss)						Proportion of greater consultation (%)					
		X	SD	M	IQR	Min	Max	X	SD	M	IQR	Min	Max
Al consultations		09:59	04:39	09:28	04:34	02:16	31:25	85.48	13.59	88.19	16.71	21.30	100.00
EPR system													
	LV	09:04	04:35	08:44	04:34	02:33	23:41	82.08	15.88	85.97	20.39	21.30	100.00
	PCS	11:49	05:35	10:45	04:33	03:15	31:25	88.80	9.71	91.09	14.25	63.21	100.00
	Vision	10:37	03:53	09:53	03:23	03:59	26:26	88.34	11.98	92.34	13.59	57.79	100.00
	Synergy	08:40	03:43	08:06	05:21	02:16	17:25	84.16	13.75	86.61	17.87	53.10	100.00
Dr ID													
LV	GP01	09:10	04:26	09:28	04:50	02:33	18:14	81.91	16.22	85.97	20.75	45.99	100.00
	GP06	08:33	04:06	07:33	06:15	05:05	14:01	92.50	8.26	93.50	13.80	83.01	100.00
	GP10b	07:29	04:46	06:24	06:16	02:55	21:16	75.59	21.08	77.98	30.33	21.30	100.00
	GP12	08:48	04:08	08:39	02:37	02:55	18:50	90.75	4.34	91.52	6.95	85.29	98.86
	GP14	11:33	04:50	10:33	04:50	06:46	23:41	79.52	11.95	82.45	15.69	53.94	96.07
PCS	GP03	15:16	06:39	13:30	04:32	08:10	31:25	89.76	7.65	91.05	7.86	71.94	100.00
	GP10a	09:18	03:01	10:01	04:49	03:15	13:06	85.23	12.69	89.35	17.43	63.21	100.00
	GP15	09:54	03:50	09:12	02:17	04:17	18:46	90.66	9.09	91.42	17.24	76.43	100.00
Synergy	GP04	09:16	02:17	08:57	03:28	06:14	13:47	77.79	14.16	84.25	21.15	53.10	95.71
	GP05	10:46	04:05	11:05	06:35	05:06	17:25	90.22	7.95	91.50	12.44	77.64	100.00
	GP08	04:31	01:44	05:11	03:12	02:16	06:44	87.32	16.03	95.51	28.63	60.36	100.00
Vision	GP02	10:33	03:21	09:31	04:30	07:17	16:59	86.31	10.43	91.98	17.20	68.45	96.32
	GP07	09:19	01:45	09:28	03:27	07:01	11:14	84.64	16.57	89.93	25.12	57.79	100.00
	GP09	10:36	02:58	10:39	04:11	06:59	15:49	92.35	7.23	92.41	13.77	84.86	100.00
	GP11	12:26	06:05	10:49	04:13	07:44	26:26	90.19	14.18	95.08	13.97	59.27	100.00
	GP13	10:02	03:50	09:28	06:25	03:59	15:26	87.39	12.34	88.49	13.65	57.99	100.00

Table 9.2: Durations and proportions of the greater consultation without examinations, interruptions and durations where doctor is not in the room, in mm:ss

		Duration (mm:ss)						Proportion of greater consultation (%)					
		X	SD	M	IQR	Min	Max	X	SD	M	IQR	Min	Max
AI consultations		08:40	04:02	08:29	04:54	01:49	24:00	74.40	14.15	77.09	18.77	11.97	100.00
EPR system													
	LV	07:51	04:11	06:51	04:39	01:49	21:44	70.80	16.28	73.52	21.09	11.97	97.69
	PCS	09:54	04:30	08:49	04:00	02:31	24:00	75.29	13.92	79.98	21.82	46.08	94.88
	Vision	09:15	03:25	08:56	03:26	03:48	22:47	76.72	10.64	78.67	15.67	53.11	96.15
	Synergy	07:59	03:33	06:48	05:30	01:53	16:05	77.06	13.36	79.18	21.39	47.83	100.00
Dr ID													
LV	GP01	08:01	03:40	08:40	05:26	02:16	13:43	72.39	15.67	75.01	18.47	39.77	94.29
	GP06	07:27	04:11	06:31	06:18	03:42	13:04	78.10	9.67	74.86	12.72	70.61	92.07
	GP10b	06:21	04:47	05:29	05:03	01:49	20:29	62.07	18.01	65.64	22.78	11.97	83.96
	GP12	08:13	03:29	08:25	02:48	02:36	15:56	85.38	6.05	84.20	6.68	77.41	97.69
	GP14	09:28	04:42	08:49	05:26	05:26	21:44	64.34	13.37	66.78	19.64	43.99	88.17
PCS	GP03	12:22	05:08	11:21	05:17	07:28	24:00	74.79	16.42	78.56	30.20	46.08	94.88
	GP10a	07:48	03:00	08:42	03:48	02:31	12:23	70.54	14.85	70.63	28.05	52.51	91.33
	GP15	08:47	03:34	08:35	02:42	03:43	17:22	79.84	8.60	80.44	9.30	63.62	92.27
Synergy	GP04	08:35	02:31	07:55	03:32	05:28	13:38	71.26	13.24	75.00	15.45	47.83	90.68
	GP05	09:56	03:44	10:45	05:37	04:23	16:05	83.27	8.60	81.41	11.28	70.09	100.00
	GP08	04:06	01:38	04:42	02:46	01:53	06:23	78.97	16.11	80.97	27.64	50.30	94.88
Vision	GP02	09:00	02:13	08:27	03:54	06:06	12:15	74.49	9.78	74.80	15.83	62.08	88.97
	GP07	08:10	01:32	07:52	02:31	06:06	10:06	73.64	10.74	75.85	16.15	57.14	84.74
	GP09	08:34	02:40	08:57	03:28	05:44	13:44	74.41	8.97	73.45	13.79	62.35	87.54
	GP11	11:11	05:18	09:47	04:38	06:30	22:47	80.61	11.42	80.95	11.59	57.36	94.53
	GP13	09:04	03:34	08:40	06:31	03:48	14:02	78.67	12.23	79.80	14.38	53.11	96.15

Table 9.3: Durations and proportions of the 'uninterrupted three actor time' (UTAT) in mm:ss

		Initial-marginal consultation				Core cosultation				Final marginal consultation			
		X	SD	M	IQR	X	SD	M	IQR	X	SD	M	IQR
AI consultations		00:38	00:46	00:26	00:34	10:21	04:43	09:51	06:06	00:59	01:18	00:28	01:19
EPR system													
	LV	00:50	00:58	00:28	00:53	09:40	04:49	08:38	05:43	00:44	00:49	00:25	01:02
	PCS	00:35	00:29	00:36	00:31	11:29	05:01	10:24	04:40	01:45	02:04	01:02	01:42
	Vision	00:33	00:41	00:22	00:27	10:52	04:32	10:29	05:14	01:05	01:06	00:52	01:41
	Synergy	00:25	00:35	00:17	00:24	09:37	04:14	09:24	06:43	00:34	00:55	00:08	00:44
Dr ID													
LV	GP01	01:23	01:19	01:03	00:40	09:34	04:42	08:40	06:14	00:24	00:37	00:12	00:15
	GP06	00:24	00:07	00:27	00:09	08:06	04:08	07:44	06:25	00:41	00:20	00:36	00:30
	GP10b	00:18	00:07	00:19	00:10	09:05	05:42	07:16	07:37	00:54	00:39	00:53	01:02
	GP12	00:12	00:12	00:10	00:13	09:03	03:41	09:21	02:47	00:24	01:00	00:04	00:05
	GP14	01:28	00:44	01:24	01:15	11:44	05:00	10:42	05:51	01:18	00:56	01:16	01:24
PCS	GP03	00:19	00:16	00:12	00:30	14:11	05:28	12:40	06:18	03:23	02:33	03:24	04:31
	GP10a	00:59	00:34	00:45	00:20	09:30	03:38	10:34	03:44	00:49	00:45	00:54	01:17
	GP15	00:29	00:19	00:33	00:30	09:58	04:20	09:22	04:38	00:42	00:32	00:33	00:58
Synergy	GP04	00:07	00:07	00:06	00:02	11:12	03:31	12:06	05:13	00:58	01:12	00:31	01:23
	GP05	00:53	00:49	00:40	00:16	10:57	03:57	10:53	05:34	00:13	00:20	00:06	00:11
	GP08	00:18	00:04	00:18	00:03	04:47	01:49	04:42	03:01	00:11	00:18	00:04	00:02
Vision	GP02	01:12	01:18	00:51	01:43	10:35	02:29	11:35	03:33	00:37	00:43	00:13	01:18
	GP07	00:03	00:02	00:02	00:02	10:09	03:16	09:51	05:50	01:23	01:12	00:57	00:51
	GP09	00:19	00:07	00:20	00:04	09:24	02:38	09:25	03:31	01:50	01:03	01:45	01:03
	GP11	00:21	00:10	00:23	00:07	13:08	07:17	10:29	09:54	01:02	01:10	00:48	01:44
	GP13	00:39	00:30	00:34	01:03	10:52	04:49	10:51	09:49	00:32	01:04	00:05	00:29

Table 9.4: Durations of initial-marginal, core and final-marginal consultations in mm:ss

		Initial-marginal consultation		Core consultation		Final marginal consultation	
		X	SD	X	SD	X	SD
Al consultations		5.89	6.38	87.52	9.38	7.94	8.15
EPR system							
	LV	7.42	7.41	85.93	9.43	7.04	7.16
	PCS	5.84	6.51	86.04	10.34	10.68	9.14
	Vision	4.77	5.28	88.14	8.91	9.05	8.43
	Synergy	4.27	4.61	91.52	7.68	5.35	7.97
Dr ID							
LV	GP01	12.29	10.10	84.61	10.63	3.82	4.33
	GP06	4.70	1.19	85.60	8.84	9.71	8.73
	GP10b	3.25	1.78	86.64	8.31	11.07	7.79
	GP12	2.83	2.86	94.44	4.94	2.73	4.85
	GP14	10.81	5.72	79.37	7.17	9.82	7.64
PCS	GP03	1.85	1.66	84.95	12.77	17.30	11.04
	GP10a	10.77	9.23	83.74	11.32	6.87	5.52
	GP15	5.38	3.58	89.24	5.03	6.46	3.78
Synergy	GP04	1.04	0.86	90.99	10.04	8.72	10.32
	GP05	7.18	5.81	92.11	5.81	1.78	2.01
	GP08	6.37	3.08	91.64	5.63	3.38	5.04
Vision	GP02	9.44	8.21	87.39	10.23	4.51	4.17
	GP07	0.36	0.20	88.61	11.18	13.31	10.93
	GP09	3.14	1.58	81.97	7.89	16.06	7.75
	GP11	2.92	1.70	90.43	7.33	7.61	6.63
	GP13	6.30	5.33	91.17	7.61	3.96	6.55

Table 9.5: Proportions of the initial-marginal, core and final-marginal consultations in mm:ss

		Intial marginal (un-interupted)		Interuptions in initial marginal		Core consultation (pre-exam)		Examination		Core consultation (post-exam)		Interuptions in core		Final marginal (un-interupted)		Interuptions in final marginal	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
Al consultations		5.79	6.32	2.88	1.47	36.53	30.53	11.26	11.90	50.65	18.78	4.88	3.49	7.63	7.84	5.56	7.50
EPR system																	
	LV	7.36	7.39	3.51	.	31.32	27.19	14.29	13.83	47.43	18.26	4.19	2.03	6.78	6.92	4.87	2.85
	PCS	5.54	6.30	3.24	1.55	36.98	30.46	9.00	9.14	53.61	18.54	4.80	3.91	10.65	9.15	0.89	.
	Vision	4.73	5.24	1.13	.	43.64	32.97	9.52	11.29	50.09	19.06	5.18	3.79	8.96	8.26	1.49	1.19
	Synergy	4.27	4.61	.	.	36.41	32.78	10.55	10.94	54.64	19.72	4.98	3.68	4.35	6.27	12.98	14.49
Dr ID																	
LV	GP01	12.29	10.10	.	.	43.47	31.43	12.03	13.66	40.96	19.67	3.36	.	3.82	4.33	.	.
	GP06	4.70	1.19	.	.	44.81	36.90	7.50	8.26	44.39	28.53	.	.	9.71	8.73	.	.
	GP10b	3.25	1.78	.	.	22.38	23.16	22.26	18.02	47.49	14.31	6.24	1.42	10.70	7.40	5.24	.
	GP12	2.83	2.86	.	.	29.48	21.79	8.55	4.56	55.90	19.54	2.55	0.04	2.54	4.31	1.85	.
	GP14	10.49	5.79	3.51	.	21.53	20.47	14.60	11.13	47.58	17.12	.	.	9.14	7.68	7.52	.
PCS	GP03	1.85	1.66	.	.	31.47	27.74	8.60	8.48	55.70	24.06	7.82	7.22	17.22	11.13	0.89	.
	GP10a	10.27	8.95	2.48	1.16	44.06	33.13	10.98	12.12	45.07	11.19	2.75	1.58	6.87	5.52	.	.
	GP15	4.98	3.65	4.77	.	37.52	32.57	7.82	7.44	56.76	14.13	7.96	3.14	6.46	3.78	.	.
Synergy	GP04	1.04	0.86	.	.	27.15	16.98	14.98	11.49	45.73	16.51	4.06	3.62	6.56	8.03	12.98	14.49
	GP05	7.18	5.81	.	.	40.70	42.77	5.88	7.76	73.64	9.37	4.48	2.04	1.78	2.01	.	.
	GP08	6.37	3.08	.	.	47.48	38.91	9.02	11.92	55.10	23.45	8.54	3.86	3.38	5.04	.	.
Vision	GP02	9.44	8.21	.	.	37.16	36.21	8.29	8.47	52.94	20.41	9.65	2.67	4.51	4.17	.	.
	GP07	0.36	0.20	.	.	38.74	35.87	13.73	14.94	54.19	24.27	.	.	12.85	10.16	2.34	.
	GP09	3.14	1.58	.	.	48.73	32.13	6.95	7.21	41.09	23.43	2.45	0.56	15.98	7.74	0.65	.
	GP11	2.92	1.70	.	.	49.59	32.33	9.81	14.18	49.64	15.45	.	.	7.61	6.63	.	.
	GP13	6.20	5.25	1.13	.	42.40	35.50	9.67	12.17	52.17	18.20	3.18	1.76	3.96	6.55	.	.

Table 9.6: Proportions of the greater consultation components with and without interruptions

		Computer use only		Computer use (Dr talk with eye contact)		Computer use (Pt talk with eye contact)		Computer use (Dr talking)		Computer use (Pt talking)		Dr talk (eye contact)		Pt talk (eye contact)		Dr talk only		Pt talk only	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
AI consultations		25.29	9.47	1.19	1.10	0.96	0.90	6.99	5.08	5.98	4.91	16.02	8.64	15.73	9.02	7.75	4.67	4.78	3.23
EPR system																			
	LV	24.15	9.39	1.02	0.89	1.00	0.94	7.07	5.42	7.19	6.17	15.16	8.76	14.24	8.58	7.62	3.96	4.55	2.61
	PCS	25.30	8.64	1.42	1.25	1.20	1.01	4.90	3.51	4.33	3.95	18.50	9.29	20.73	10.04	7.94	6.22	5.82	4.67
	Vision	29.85	9.52	1.43	1.29	0.91	0.92	6.78	4.11	5.43	3.71	16.93	8.45	14.47	9.06	6.19	3.49	3.75	2.38
	Synergy	21.37	8.46	0.92	0.92	0.65	0.54	9.59	6.13	6.39	4.10	13.43	7.19	14.25	6.35	9.83	4.54	5.33	2.83
Dr ID																			
LV	**GP01**	21.74	7.52	0.94	0.89	0.85	0.74	9.90	6.39	8.02	5.60	14.17	9.05	12.79	7.60	9.46	5.11	4.09	1.99
	GP06	24.26	10.16	0.71	0.59	0.74	0.72	6.82	4.43	7.75	4.42	16.86	4.26	17.51	8.64	5.13	1.65	4.28	2.23
	GP10b	30.56	11.44	1.38	0.97	1.11	1.00	5.73	4.28	5.23	4.39	10.29	5.10	10.00	6.66	6.92	2.64	4.53	2.77
	GP12	20.80	9.69	1.52	0.89	1.67	1.23	9.48	4.34	13.35	7.97	18.56	12.41	17.26	11.74	5.32	2.68	3.56	1.74
	GP14	22.14	4.22	0.32	0.20	0.57	0.65	2.44	2.19	2.78	2.57	19.63	6.82	18.35	7.00	8.75	3.63	6.27	3.51
PCS	**GP03**	25.97	10.56	1.08	0.89	1.06	0.99	3.80	2.54	3.14	2.05	19.13	7.95	18.79	9.79	11.25	5.20	6.49	4.82
	GP10a	27.26	8.88	0.94	0.83	0.85	1.00	4.16	2.78	5.97	5.99	13.83	9.40	16.39	5.92	8.62	7.99	7.21	5.93
	GP15	22.89	5.54	2.22	1.55	1.65	0.93	6.80	4.38	4.35	3.32	21.67	9.80	26.60	10.91	3.51	1.80	3.89	2.60
Synergy	**GP04**	23.61	8.63	0.39	0.35	0.46	0.43	5.36	3.62	5.67	4.07	11.18	4.91	16.02	7.48	9.48	3.46	5.53	3.33
	GP05	14.58	4.59	1.26	1.08	0.52	0.32	10.22	5.24	5.28	3.35	20.18	6.21	14.48	5.21	10.59	5.77	5.37	2.65
	GP08	26.93	6.46	1.42	1.01	1.18	0.67	16.54	4.27	9.29	4.28	7.98	4.71	10.64	4.49	9.38	4.94	4.89	2.39
Vision	**GP02**	31.08	3.38	1.25	0.60	0.59	0.28	7.84	3.86	4.97	3.28	10.34	2.18	9.82	4.65	8.80	2.35	5.09	2.33
	GP07	34.05	5.66	0.75	0.57	0.55	0.28	5.85	3.77	5.89	4.50	15.69	3.91	13.19	6.48	4.83	3.03	4.61	2.83
	GP09	36.39	11.99	3.03	1.78	2.24	1.32	5.37	3.38	4.73	3.38	13.43	7.31	14.69	12.13	4.83	3.80	2.42	1.67
	GP11	22.29	7.72	0.84	0.50	0.47	0.23	10.50	4.44	6.29	4.55	26.11	11.16	13.72	6.90	6.86	4.68	3.06	1.83
	GP13	27.54	9.55	1.17	1.03	0.65	0.42	4.95	3.24	5.36	3.64	17.68	5.85	18.53	10.74	5.77	2.47	3.90	2.66

Table 9.7: Distribution of the computer use and doctor-patient verbal and non-verbal interactions in as proportions of the greater consultation (using nine categories)

		Computer use (no Dr-Pt interactions)		Computer use (while Dr-Pt interacting)		Dr-Pt interaction outside computer use		Examination	
		X	SD	X	SD	X	SD	X	SD
AI consultations		02:56	01:44	01:38	01:09	05:25	03:28	01:27	01:55
EPR system									
	LV	02:36	01:32	01:46	01:28	04:45	02:55	01:41	02:14
	PCS	03:24	02:07	01:25	00:54	07:27	04:55	01:22	01:37
	Vision	03:37	01:45	01:39	00:56	05:07	02:36	01:24	02:04
	Synergy	02:04	00:56	01:37	01:00	04:41	02:25	01:12	01:23
Dr ID									
LV	GP01	02:18	01:13	02:12	01:29	04:48	03:02	01:31	02:46
	GP06	01:57	00:24	01:30	00:50	04:13	02:38	00:39	00:39
	GP10b	02:49	01:20	01:22	01:20	03:24	02:49	02:22	02:29
	GP12	02:23	02:31	02:39	01:38	03:46	01:14	00:47	00:28
	GP14	03:12	01:21	00:57	01:11	07:35	02:21	02:10	02:04
PCS	GP03	04:32	02:47	01:22	00:40	10:04	06:26	01:38	02:00
	GP10a	03:00	01:25	01:11	00:54	05:21	02:28	01:26	01:34
	GP15	02:24	00:46	01:41	01:06	06:10	02:55	01:01	01:10
Synergy	GP04	02:42	00:50	01:26	00:58	05:13	01:57	01:58	01:41
	GP05	01:45	00:48	01:56	01:14	06:00	02:07	00:43	00:51
	GP08	01:19	00:22	01:31	00:42	01:47	00:52	00:28	00:34
Vision	GP02	03:50	01:18	01:43	00:36	04:17	01:48	01:03	01:01
	GP07	03:50	01:11	01:18	00:39	04:17	01:04	01:49	02:06
	GP09	03:56	00:36	01:52	01:21	04:17	02:39	00:45	00:47
	GP11	03:22	02:47	02:14	00:54	06:55	03:18	01:58	03:27
	GP13	03:20	02:03	01:12	00:42	05:25	02:40	01:29	02:03

Table 9.8: Durations of the computer use and doctor-patient verbal and non-verbal interaction episodes

		Computer use (no Dr-Pt interactions)		Computer use (while Dr-Pt interacting)		Dr-Pt interaction outside computer use		Examination		No Dr-Pt-Comp interactions	
		X	SD	X	SD	X	SD	X	SD	X	SD
Al consultations		25.29	9.47	15.11	9.26	44.27	13.85	11.26	11.90	4.06	10.32
EPR system											
	LV	24.15	9.39	16.29	10.72	41.58	14.88	14.29	13.83	3.69	9.18
	PCS	25.30	8.64	11.85	7.44	52.99	13.36	9.00	9.14	0.86	12.93
	Vision	29.85	9.52	14.55	7.85	41.35	12.71	9.52	11.29	4.73	7.03
	Synergy	21.37	8.46	17.54	9.21	42.84	9.46	10.55	10.94	7.69	11.69
Dr ID											
LV	GP01	21.74	7.52	19.71	8.59	40.51	14.31	12.03	13.66	6.01	10.95
	GP06	24.26	10.16	16.01	5.42	43.77	8.60	7.50	8.26	8.45	4.20
	GP10b	30.56	11.44	13.46	9.03	31.74	10.98	22.26	18.02	1.98	10.48
	GP12	20.80	9.69	26.02	12.34	44.70	20.03	8.55	4.56	-0.07	6.25
	GP14	22.14	4.22	6.12	5.01	53.00	7.62	14.60	11.13	4.15	7.02
PCS	GP03	25.97	10.56	9.08	5.10	55.66	13.28	8.60	8.48	0.70	16.19
	GP10a	27.26	8.88	11.92	9.14	46.05	14.31	10.98	12.12	3.79	15.23
	GP15	22.89	5.54	15.02	7.52	55.66	11.45	7.82	7.44	-1.39	4.37
Synergy	GP04	23.61	8.63	11.87	6.73	42.20	8.52	14.98	11.49	7.33	10.58
	GP05	14.58	4.59	17.28	7.73	50.63	5.64	5.88	7.76	11.63	14.70
	GP08	26.93	6.46	28.43	4.67	32.89	4.76	9.02	11.92	2.73	7.61
Vision	GP02	31.08	3.38	14.65	5.93	34.05	6.70	8.29	8.47	11.94	5.49
	GP07	34.05	5.66	13.04	8.61	38.31	7.02	13.73	14.94	0.87	6.71
	GP09	36.39	11.99	15.37	9.12	35.37	17.41	6.95	7.21	5.92	5.37
	GP11	22.29	7.72	18.10	8.21	49.75	10.62	9.81	14.18	0.05	6.20
	GP13	27.54	9.55	12.13	7.64	45.88	11.70	9.67	12.17	4.77	6.39

Table 9.9: Distribution of the computer use and doctor-patient verbal and non-verbal interactions in as proportions of the greater consultation (using four categories)

		Greater consultation		Initial-marginal consultation		Core consultation		Final marginal consultation	
		X	SD	X	SD	X	SD	X	SD
AI consultations		04:35	02:21	00:22	00:29	03:25	02:00	00:48	01:12
EPR system									
	LV	04:23	02:39	00:27	00:35	03:19	02:21	00:37	00:45
	PCS	04:50	02:23	00:25	00:20	03:04	01:45	01:21	01:53
	Vision	05:17	02:10	00:22	00:31	04:04	01:56	00:52	01:03
	Synergy	03:42	01:31	00:11	00:19	03:09	01:29	00:22	00:48
Dr ID									
LV	**GP01**	04:32	02:28	00:44	00:51	03:34	01:41	00:13	00:22
	GP06	03:28	01:08	00:04	00:02	02:43	01:09	00:40	00:21
	GP10b	04:12	02:36	00:15	00:08	03:09	02:24	00:48	00:40
	GP12	05:03	03:51	00:11	00:11	04:30	03:11	00:22	00:55
	GP14	04:10	02:24	00:41	00:34	02:17	02:27	01:11	00:54
PCS	**GP03**	05:55	02:53	00:08	00:11	03:15	01:50	02:32	02:32
	GP10a	04:11	01:57	00:44	00:12	02:48	02:01	00:39	00:45
	GP15	04:06	01:37	00:28	00:19	03:04	01:34	00:35	00:33
Synergy	**GP04**	04:09	01:32	00:00	00:01	03:28	01:46	00:40	01:08
	GP05	03:43	01:43	00:23	00:29	03:11	01:24	00:09	00:18
	GP08	02:53	00:57	00:13	00:07	02:31	00:51	00:09	00:17
Vision	**GP02**	05:34	01:37	00:42	01:00	04:19	01:07	00:33	00:42
	GP07	05:10	01:12	00:00	00:00	04:08	01:46	01:02	01:09
	GP09	05:50	01:34	00:09	00:09	03:54	02:04	01:47	01:01
	GP11	05:38	03:15	00:19	00:10	04:29	02:27	00:50	01:05
	GP13	04:33	02:24	00:33	00:26	03:40	02:10	00:20	00:52

Table 9.10: Distribution of the computer use durations in initial, final marginal and core consultations

		Greater consultation		Initial-marginal consultation		Core consultation		Final marginal consultation	
		X	SD	X	SD	X	SD	X	SD
Al consultations		40.62	13.76	59.33	34.78	34.96	15.62	74.63	35.31
EPR system									
	LV	40.66	15.62	61.88	31.47	35.64	17.82	71.03	35.35
	PCS	37.29	11.78	69.36	33.14	28.51	13.34	91.75	20.28
	Vision	44.60	11.71	62.84	35.31	38.54	13.68	78.15	33.22
	Synergy	39.20	14.05	37.32	35.09	36.65	14.46	58.70	43.21
Dr ID									
LV	GP01	41.84	13.03	52.09	26.36	41.02	14.66	38.37	26.61
	GP06	40.36	13.00	20.02	10.95	35.56	8.90	95.55	8.89
	GP10b	44.18	18.76	90.37	8.18	36.72	18.64	90.52	26.10
	GP12	47.11	17.15	78.59	20.35	44.59	18.68	77.78	31.95
	GP14	28.31	7.51	39.89	31.74	17.77	11.35	81.62	34.01
PCS	GP03	35.18	11.01	41.75	30.41	24.53	11.10	89.83	14.65
	GP10a	39.27	15.48	83.71	20.69	31.39	17.74	85.63	34.77
	GP15	38.11	9.60	82.72	29.34	30.74	11.40	98.75	2.91
Synergy	GP04	35.57	12.87	9.32	18.15	32.24	13.86	43.64	38.86
	GP05	32.08	9.78	46.17	28.44	30.34	9.56	74.22	42.51
	GP08	56.10	5.75	80.04	13.09	53.84	6.00	68.13	49.45
Vision	GP02	45.92	6.98	41.27	34.84	41.60	9.54	68.32	34.95
	GP07	47.23	12.31	8.76	19.59	41.52	14.87	70.35	40.59
	GP09	52.10	13.11	77.12	7.94	41.66	20.48	95.92	4.67
	GP11	40.66	10.06	76.18	35.19	35.42	9.98	81.98	36.88
	GP13	39.75	12.23	82.98	12.41	34.99	12.66	69.41	40.91

Table 9.11: Distribution of the computer use in initial, final marginal and core consultations as proportions of each component

		Reviewing record		Recording data		Taking actions		Looking at the screen - default view		Overheads - delays, navigation and prompts	
		X	SD	X	SD	X	SD	X	SD	X	SD
AI consultations		7.55	7.28	15.01	8.09	9.30	8.84	10.00	15.07	6.72	5.72
EPR system											
	LV	7.81	6.21	16.67	7.96	10.53	10.50	12.83	17.43	6.39	3.77
	PCS	4.77	4.69	13.85	7.93	6.80	6.58	9.39	9.65	5.76	5.27
	Vision	7.18	5.53	16.79	7.50	11.13	9.38	8.08	17.85	8.34	8.62
	Synergy	10.90	11.52	10.86	7.90	7.55	5.87	7.90	10.70	6.34	4.10
Dr ID											
LV	GP01	8.62	6.45	17.95	6.96	11.05	7.54	32.35	20.51	7.34	5.46
	GP06	8.53	9.76	12.45	6.55	8.74	2.77	9.01	2.99	3.51	1.25
	GP10b	8.69	6.78	20.47	7.59	13.08	13.28	5.65	5.57	6.54	2.87
	GP12	7.38	5.51	14.34	10.22	13.46	14.47	2.66	5.82	5.92	3.02
	GP14	5.50	4.55	13.14	6.26	4.25	4.96	3.08	3.69	6.19	2.54
PCS	GP03	2.82	4.38	14.18	11.05	7.00	6.52	14.31	10.06	2.71	2.82
	GP10a	4.44	3.91	15.90	6.21	4.87	6.09	8.26	7.47	10.15	7.17
	GP15	7.31	4.77	11.77	3.96	8.16	7.18	4.58	8.58	5.66	2.75
Synergy	GP04	7.70	7.24	12.99	8.37	3.79	3.81	10.08	9.51	6.19	5.27
	GP05	8.61	5.43	5.91	5.95	7.43	5.11	4.44	4.17	6.61	3.29
	GP08	20.10	19.03	13.96	6.82	14.69	2.87	8.78	17.75	6.23	3.01
Vision	GP02	7.68	5.23	14.47	8.19	11.32	10.04	10.64	3.55	5.39	2.26
	GP07	8.45	9.07	23.46	4.77	8.76	8.39	24.82	42.11	6.79	2.83
	GP09	4.16	2.94	16.29	6.91	13.21	10.20	1.35	6.17	18.25	15.28
	GP11	7.47	5.09	14.47	3.17	12.09	11.37	3.20	5.33	5.28	2.46
	GP13	8.16	5.31	16.67	9.62	10.09	8.69	5.75	8.20	6.07	3.97

Table 9.12: Distribution of the computer use tasks - 5 category summary – as proportions of the greater un-interrupted greater consultation

		Past encounter review		Examination finding review		Letter reading		Test results review		Coded data entry		Free text entry		BP entry
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X
AI consultations		12.96	15.19	22.80	16.70	14.57	30.26	14.99	13.57	9.13	13.83	5.54	5.34	8.50
EPR system														
	LV	10.60	11.72	11.12	7.78	38.96	52.97	3.27	0.40	14.05	22.85	7.64	6.34	6.64
	PCS	15.23	14.84	.	.	1.41	.	21.06	22.42	15.65	12.13	4.40	3.94	18.44
	Vision	11.95	14.51	34.52	19.11	4.60	4.31	16.56	8.58	5.21	4.73	3.82	3.96	5.23
	Synergy	15.65	20.57	22.70	.	4.54	4.06	12.83	10.40	5.56	4.24	2.09	2.37	4.18
Dr ID														
LV	**GP01**	4.88	3.42	9.81	.	.	.	3.27	0.40	14.97	24.36	8.12	7.31	.
	GP06	13.79	10.18	.	.	5.01	.	.	.	.	.	6.52	3.92	.
	GP10b	16.03	17.07	11.78	10.89	55.94	62.32	.	.	3.66	.	5.35	6.08	17.31
	GP12	10.03	9.92	.	.	.	.	.	.	3.48	0.53	9.49	6.65	1.89
	GP14	2.30	.	.	.	.	.	.	.	61.13	.	6.08	5.52	10.22
PCS	**GP03**	17.41	10.36	.	.	.	.	5.48	.	.	.	5.11	4.37	.
	GP10a	5.27	6.27	.	.	.	.	.	.	19.40	.	2.23	1.72	.
	GP15	18.67	18.78	.	.	1.41	.	26.26	24.33	14.72	13.80	7.19	4.65	18.44
Synergy	**GP04**	24.17	30.90	22.70	.	10.09	.	6.48	8.49	5.55	6.49	0.81	.	4.18
	GP05	7.96	8.31	.	.	2.69	2.05	19.18	9.53	6.48	2.58	4.83	.	.
	GP08	16.01	14.54	.	.	.	.	.	.	2.80	.	0.64	.	.
Vision	**GP02**	6.17	6.90	.	.	.	.	14.48	12.22	10.01	6.77	3.94	5.48	5.23
	GP07	11.49	13.78	.	.	.	.	.	.	6.64	2.63	2.45	2.78	.
	GP09	27.44	23.27	44.77	10.01	.	.	17.28	.	6.47	7.88	0.06	.	.
	GP11	6.36	4.99	.	.	4.60	4.31	18.28	11.41	3.09	1.97	4.72	5.03	.
	GP13	8.15	5.69	14.02	.	.	.	.	.	3.88	5.31	4.83	3.79	.

Table 9.13: Amount of doctor-patient eye-contact, as a proportion of reviewing and data entry tasks

		Medication review		Acute prescribing		Repeat prescribing - new		Repeat prescribing - old		Issueing prescriptions	
		X	SD	X	SD	X	SD	X	SD	X	SD
Al consultations		21.69	19.28	17.04	15.19	3.10	1.97	21.48	23.39	28.35	25.02
EPR system											
	LV	15.84	11.39	20.52	18.04	2.90	.	12.41	14.30	20.27	15.85
	PCS	31.89	27.80	15.20	13.54	.	.	29.46	23.60	28.57	24.34
	Vision	29.65	21.53	13.34	13.60	3.17	2.41	32.56	35.22	29.81	26.59
	Synergy	10.65	4.00	19.44	12.81	.	.	6.55	5.58	42.46	36.40
Dr ID											
LV	GP01	16.80	11.77	19.74	24.72	.	.	5.46	0.14	27.81	15.90
	GP06	6.17	4.29	20.79	8.98	.	.	.	.	9.71	.
	GP10b	9.74	7.49	17.26	14.58	.	.	.	.	2.09	.
	GP12	18.46	10.70	22.85	12.96	2.90	.	11.84	11.34	10.40	.
	GP14	29.84	10.06	31.52	22.00	.	.	19.92	26.16	9.41	3.94
PCS	GP03	34.53	28.60	16.55	11.05	.	.	1.48	.	.	.
	GP10a	20.61	13.77	9.04	5.90	.	.	.	.	0.08	.
	GP15	33.98	32.59	18.63	18.38	.	.	36.46	20.41	34.27	22.30
Synergy	GP04	13.48	.	9.33	.	.	.	.	.	.	.
	GP05	7.82	.	21.73	13.78	.	.	.	.	74.67	13.81
	GP08	.	.	13.57	.	.	.	6.55	5.58	10.26	3.17
Vision	GP02	.	.	11.76	16.22	4.02	2.70	18.21	24.87	.	.
	GP07	.	.	3.56	0.40	.	.	.	.	44.91	42.98
	GP09	33.32	13.97	16.29	8.73	.	.	80.67	.	30.46	34.84
	GP11	4.30	3.45	4.52	4.54	1.47	.	13.15	.	17.74	20.24
	GP13	40.48	20.45	16.89	20.10	.	.	.	.	30.72	5.63

Table 9.14: Amount of doctor-patient eye-contact, as a proportion of prescribing tasks

		Writing letters		Referrals		Test requests		System delays and errors		Transitions outside events		Prompts	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
AI consultations		3.94	3.31	6.52	9.02	13.46	11.93	25.76	24.75	7.01	6.57	14.03	11.29
EPR system													
	LV	1.60	.	8.32	5.91	15.73	4.83	6.58	8.18	6.25	5.54	12.66	13.04
	PCS	6.28	.	2.81	4.09	26.15	12.77	45.38	.	6.34	5.44	9.63	5.66
	Vision	.	.	1.84	1.67	7.84	10.18	32.85	26.30	7.42	7.82	17.48	13.81
	Synergy	.	.	28.05	.	.	.	1.99	.	9.17	8.08	15.70	10.30
Dr ID													
LV	GP01	.	.	4.14	.	20.93	.	.	.	4.23	3.10	32.94	15.76
	GP06	.	.	.	.	.	.	.	.	10.98	9.53	.	.
	GP10b	1.60	.	.	.	.	.	6.58	8.18	7.80	8.23	8.10	4.70
	GP12	.	.	12.50	.	13.14	2.48	.	.	6.35	3.89	5.41	1.77
	GP14	.	.	.	.	.	.	.	.	6.19	6.52	10.21	.
PCS	GP03	6.28	.	3.99	5.01	33.21	.	.	.	5.08	4.77	8.54	2.35
	GP10a	.	.	0.44	.	.	.	45.38	.	2.37	1.67	3.50	.
	GP15	.	.	.	.	22.63	15.86	.	.	10.36	5.29	11.20	6.65
Synergy	GP04	.	.	28.05	.	.	.	.	.	7.20	8.75	8.24	5.74
	GP05	.	.	.	.	.	.	1.99	.	7.18	3.69	18.39	11.49
	GP08	.	.	.	.	.	.	.	.	15.61	12.78	14.50	.
Vision	GP02	.	.	.	.	.	.	.	.	5.01	3.10	5.75	2.96
	GP07	.	.	.	.	0.66	.	.	.	6.00	3.92	11.44	11.61
	GP09	.	.	.	.	22.14	7.15	32.85	26.30	15.79	10.58	14.86	6.93
	GP11	.	.	.	.	1.35	1.68	.	.	4.17	1.58	22.99	.
	GP13	.	.	1.84	1.67	6.88	8.98	.	.	3.00	2.56	39.04	20.51

Table 9.15: Amount of doctor-patient eye-contact, as a proportion of taking action and overhead tasks

		Past encounter review		Examination finding review		Letter reading		Test results review		Coded data entry		Free text entry		BP entry	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
AI consultations		26.95	18.09	48.56	18.60	25.42	18.99	45.79	25.19	19.84	17.64	14.93	16.36	23.26	16.32
EPR system															
	LV	24.45	18.11	49.58	16.69	20.09	17.41	30.31	27.64	21.05	18.45	16.85	16.76	24.92	16.41
	PCS	23.94	15.36	.	.	17.12	8.52	44.23	25.75	23.47	18.56	14.97	15.35	26.38	19.95
	Vision	27.49	19.65	35.85	19.04	17.70	0.67	54.21	25.89	16.46	13.10	8.40	8.25	27.06	19.33
	Synergy	32.82	17.85	55.16	20.03	36.85	22.10	49.97	20.23	20.92	22.50	23.18	24.71	14.71	10.08
Dr ID															
LV	GP01	25.71	25.40	66.18	.	58.05	.	48.09	43.61	27.98	21.27	21.71	17.72	30.77	14.08
	GP06	28.53	21.73	.	.	29.52	.	.	.	.	.	3.33	1.73	.	.
	GP10b	25.33	13.81	45.91	19.57	17.39	12.27	15.24	.	8.88	4.70	5.73	5.29	15.51	18.19
	GP12	24.73	10.43	43.97	.	7.62	7.08	13.57	.	19.24	12.87	23.81	18.42	20.91	11.94
	GP14	15.80	24.99	.	.	18.21	.	26.55	.	12.11	12.67	5.55	5.78	38.10	21.70
PCS	GP03	24.17	17.45	.	.	.	.	29.19	14.54	39.57	23.17	19.53	12.59	.	.
	GP10a	16.28	8.12	.	.	.	.	.	.	23.03	18.09	9.50	9.25	29.17	.
	GP15	27.22	15.97	.	.	17.12	8.52	50.25	27.98	19.00	17.90	19.41	21.70	25.69	22.97
Synergy	GP04	31.49	15.01	60.84	24.81	43.84	17.60	45.63	34.39	8.93	3.97	5.05	1.35	15.30	10.91
	GP05	27.17	17.02	46.65	11.49	31.62	26.17	52.87	14.00	34.08	35.70	34.67	25.07	11.12	.
	GP08	43.29	21.20	.	.	.	.	.	.	25.45	12.21	29.82	30.57	.	.
Vision	GP02	19.18	14.66	33.16	.	.	.	52.23	15.35	15.70	12.16	8.88	9.46	26.72	11.69
	GP07	27.68	15.30	.	.	.	.	.	.	13.85	12.40	3.22	1.35	.	.
	GP09	34.89	25.91	18.29	.	.	.	10.82	.	17.65	12.56	1.52	0.32	0.74	.
	GP11	35.14	20.85	.	.	17.70	0.67	78.49	1.45	19.29	19.77	14.15	11.26	54.74	.
	GP13	18.59	14.90	56.08	.	.	.	30.71	.	15.24	8.90	10.29	7.31	.	.

Table 9.16: Amount of doctor to patient verbal interactions, as a proportion of reviewing and data entry tasks

		Medication review		Acute prescribing		Repeat prescribing - new		Repeat prescribing - old		Issueing prescriptions	
		X	SD	X	SD	X	SD	X	SD	X	SD
Al consultations		41.27	28.71	32.26	17.44	20.75	7.26	24.51	19.62	36.23	27.31
EPR system											
	LV	36.15	20.15	32.58	17.94	15.71	2.61	17.57	14.13	31.34	22.41
	PCS	50.14	47.59	28.36	14.68	.	.	34.13	29.93	26.83	27.74
	Vision	41.18	27.54	31.18	17.91	22.92	7.66	32.39	21.47	36.63	26.32
	Synergy	51.81	27.50	39.98	19.16	.	.	34.61	17.99	55.25	32.85
Dr ID											
LV	GP01	45.73	22.67	45.66	15.45	16.02	.	25.75	24.00	41.24	21.43
	GP06	34.17	12.68	30.77	10.72	.	.	7.46	8.33	15.78	.
	GP10b	26.69	11.11	18.86	15.15	.	.	12.09	9.58	9.15	.
	GP12	25.80	17.26	35.59	10.90	15.56	3.67	26.67	4.91	33.62	16.50
	GP14	33.97	19.87	18.93	14.81	.	.	16.75	8.50	5.39	5.34
PCS	GP03	92.24	83.62	24.81	12.85	.	.	2.44	.	0.36	.
	GP10a	60.45	36.58	24.63	8.02	.	.	.	.	10.21	0.26
	GP15	29.15	12.74	35.09	19.13	.	.	42.06	27.85	36.78	29.35
Synergy	GP04	33.32	21.68	30.61	18.76	.	.	.	.	14.05	.
	GP05	83.96	17.89	45.30	19.01	.	.	49.61	.	75.31	18.95
	GP08	56.63	8.94	35.40	25.76	.	.	27.12	17.60	35.55	34.06
Vision	GP02	.	.	30.91	24.47	22.44	7.38	18.85	14.43	.	.
	GP07	56.30	2.48	29.67	9.61	.	.	.	.	56.64	29.13
	GP09	27.80	20.89	25.03	13.37	34.47	.	47.55	.	33.48	29.26
	GP11	43.08	32.97	42.53	10.39	16.15	.	57.83	.	18.21	6.11
	GP13	42.70	39.20	33.36	23.99	20.05	.	.	.	54.17	25.64

Table 9.17: Amount of doctor to patient verbal interactions, as a proportion of prescribing tasks

		Writing letters		Referrals		Test requests		System delays and errors		Transitions outside events		Prompts	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
Al consultations		40.11	29.74	30.14	30.84	34.33	23.06	23.44	16.98	17.39	11.59	26.59	19.87
EPR system													
	LV	22.69	16.42	26.57	21.30	57.83	26.22	9.99	5.52	17.10	11.49	20.55	16.87
	PCS	10.82	.	14.50	12.18	23.58	25.12	18.60	.	14.93	11.33	21.46	13.86
	Vision	75.50	.	21.82	27.11	30.29	9.70	27.33	19.40	18.37	11.58	33.27	24.11
	Synergy	71.92	5.81	83.91	22.76	7.53	6.17	30.73	18.68	19.52	12.11	26.67	17.99
Dr ID													
LV	**GP01**	37.82	.	50.29	.	86.78	12.08	15.16	.	23.84	10.72	28.88	11.01
	GP06	.	.	.	.	.	.	.	.	16.35	11.62	.	.
	GP10b	9.27	9.05	9.09	.	.	.	7.41	4.58	10.60	6.61	13.11	17.76
	GP12	34.39	.	20.32	.	45.18	19.21	.	.	21.80	13.90	20.35	22.72
	GP14	.	.	.	.	37.90	.	.	.	9.40	6.32	17.27	10.42
PCS	**GP03**	10.82	.	16.66	16.40	19.78	.	.	.	11.58	11.33	19.40	18.82
	GP10a	.	.	10.19	.	7.08	.	18.60	.	12.98	10.65	16.07	15.15
	GP15	.	.	.	.	33.73	37.43	.	.	20.30	10.67	27.83	3.64
Synergy	**GP04**	.	.	100.00	.	7.53	6.17	9.41	.	16.36	13.38	17.85	18.02
	GP05	76.03	.	.	.	.	.	41.38	4.05	21.98	10.66	28.10	16.88
	GP08	67.82	.	67.82	.	.	.	.	.	22.27	11.86	37.54	20.02
Vision	**GP02**	75.50	.	75.50	.	31.51	19.20	.	.	21.30	12.68	32.21	26.02
	GP07	.	.	.	.	24.23	4.45	.	.	25.28	13.81	32.80	4.88
	GP09	.	.	22.47	.	38.85	12.13	27.33	19.40	16.57	11.59	24.12	13.37
	GP11	.	.	.	.	32.49	5.57	.	.	19.27	13.69	51.97	36.56
	GP13	.	.	8.24	4.32	23.25	2.37	.	.	13.39	6.37	29.41	21.76

Table 9.18: Amount of doctor to patient verbal interactions, as a proportion of taking action and overhead tasks

		Reviewing record		Recording data		Taking actions		Overheads - delays, navigation and prompts	
		X	SD	X	SD	X	SD	X	SD
AI consultations		77.23	24.49	46.65	22.37	67.80	24.80	75.86	13.08
EPR system									
	LV	76.47	27.97	55.24	23.75	67.48	17.77	70.49	12.32
	PCS	73.65	28.17	50.19	17.40	74.98	36.11	80.09	11.29
	Vision	79.69	16.82	29.88	15.05	64.62	16.17	79.41	13.13
	Synergy	79.09	22.80	49.01	21.54	64.95	30.31	76.29	13.44
Dr ID									
LV	GP01	67.03	35.68	80.46	11.82	75.23	17.14	81.09	7.87
	GP06	63.94	35.41	30.47	10.35	59.82	2.06	53.28	7.99
	GP10b	79.75	21.10	44.18	11.91	66.43	16.82	66.41	8.92
	GP12	85.51	11.62	36.96	24.20	60.93	19.18	69.03	11.20
	GP14	82.33	30.92	56.95	18.19	62.47	21.17	67.23	12.63
PCS	GP03	65.14	30.35	44.06	13.57	83.00	53.38	76.51	9.93
	GP10a	93.49	17.69	38.63	10.59	77.38	7.20	90.16	10.25
	GP15	67.51	27.33	65.49	14.73	65.64	21.79	75.88	8.68
Synergy	GP04	75.24	33.06	41.34	12.86	67.28	34.21	75.92	16.23
	GP05	84.00	9.81	66.91	25.10	71.11	15.94	79.83	10.15
	GP08	77.95	16.17	44.74	23.29	53.16	40.64	71.19	11.74
Vision	GP02	88.14	7.61	33.84	7.36	50.67	9.63	86.40	9.70
	GP07	77.59	20.36	15.61	6.95	74.31	8.72	77.76	6.91
	GP09	62.96	22.14	23.54	15.09	63.34	17.93	64.64	15.58
	GP11	84.42	8.44	32.88	11.29	66.39	14.43	86.12	11.32
	GP13	84.17	12.34	37.57	18.46	70.46	17.32	81.72	8.95

Table 9.19: Proportions of the task duration doctor was looking at the screen

		Reviewing record		Recording data		Taking actions		Overheads - delays, navigation and prompts	
		X	SD	X	SD	X	SD	X	SD
AI consultations		9.29	13.63	3.04	5.55	11.46	13.33	5.08	6.35
EPR system									
	LV	5.52	10.19	4.21	6.41	11.27	12.71	4.10	5.16
	PCS	11.57	15.09	2.80	3.51	15.38	16.61	5.66	5.62
	Vision	11.25	11.92	1.89	2.64	11.17	13.19	5.63	8.10
	Synergy	11.51	18.70	2.56	8.23	8.01	9.94	5.53	6.71
Dr ID									
LV	GP01	1.68	2.84	6.73	8.28	12.12	16.85	3.21	3.18
	GP06	13.56	10.40	2.78	3.53	13.80	6.32	8.23	9.52
	GP10b	10.80	15.26	1.30	2.74	8.91	11.05	3.26	6.01
	GP12	7.00	9.59	6.33	6.35	13.50	9.59	6.10	3.84
	GP14	0.23	0.73	2.90	6.26	9.56	11.64	3.28	5.30
PCS	GP03	10.96	11.97	1.50	2.38	12.51	15.23	3.44	4.13
	GP10a	3.29	5.47	2.13	1.55	7.21	5.53	3.43	5.39
	GP15	17.59	19.35	4.70	4.78	22.69	19.75	10.10	4.91
Synergy	GP04	16.17	26.45	0.42	0.62	4.43	9.29	2.55	5.55
	GP05	5.27	6.58	8.45	15.02	14.98	9.72	7.78	5.78
	GP08	13.35	14.56	0.30	0.55	2.65	4.61	8.25	8.74
Vision	GP02	6.44	4.59	1.94	2.76	6.21	10.01	2.46	2.67
	GP07	11.49	13.78	1.71	1.58	4.52	6.48	4.53	3.48
	GP09	24.50	17.50	0.29	0.68	16.90	14.07	16.32	12.86
	GP11	6.34	4.36	2.06	3.04	6.73	6.82	2.69	2.41
	GP13	8.13	5.70	2.98	3.35	15.39	17.21	2.61	3.09

Table 9.20: Proportions of the task duration doctor was looking at the patient

		Reviewing record		Recording data		Taking actions		Overheads - delays, navigation and prompts	
		X	SD	X	SD	X	SD	X	SD
AI consultations		22.88	19.33	10.52	13.28	31.52	24.60	16.83	11.80
EPR system									
	LV	15.76	18.76	10.43	11.26	29.57	17.53	14.93	11.47
	PCS	22.04	18.39	10.12	13.33	29.61	28.86	14.01	10.41
	Vision	25.38	17.57	7.57	8.29	33.97	27.96	19.87	12.38
	Synergy	34.62	18.38	15.79	20.79	33.95	27.16	19.87	12.17
Dr ID									
LV	**GP01**	13.77	23.01	19.44	12.50	41.46	15.82	22.13	11.06
	GP06	29.58	21.03	1.56	2.15	36.25	7.76	12.26	12.52
	GP10b	19.72	16.43	2.91	5.18	19.01	13.15	9.55	6.64
	GP12	17.95	13.50	17.56	6.98	28.99	17.16	20.41	13.08
	GP14	6.88	16.69	3.49	4.28	17.12	14.74	7.11	6.84
PCS	**GP03**	23.38	17.69	7.03	11.11	33.62	43.86	11.08	10.24
	GP10a	10.18	10.42	9.50	8.79	21.03	6.91	10.66	9.27
	GP15	28.82	20.31	13.92	17.75	30.28	15.44	20.22	9.36
Synergy	**GP04**	32.15	16.62	4.69	4.34	23.57	29.64	15.53	13.06
	GP05	32.14	18.83	32.83	29.82	45.42	23.72	23.46	11.85
	GP08	43.29	21.20	19.97	17.33	30.92	25.80	23.30	8.80
Vision	**GP02**	23.69	11.95	11.35	8.06	34.06	26.65	21.36	13.65
	GP07	27.68	15.30	4.28	3.86	34.91	13.18	25.54	13.97
	GP09	25.72	14.95	1.76	1.89	23.25	15.76	18.17	12.72
	GP11	38.13	23.10	11.98	12.64	42.89	22.25	23.64	14.40
	GP13	15.70	15.27	7.98	6.93	36.76	42.29	14.33	7.86

Table 9.21: Proportions of the task duration doctor was talking to the patient

		Reviewing record		Recording data		Taking actions		Overheads - delays, navigation and prompts	
		X	SD	X	SD	X	SD	X	SD
AI consultations		18.62	18.70	13.08	17.23	21.45	19.74	16.86	12.58
EPR system									
	LV	13.54	16.86	17.77	21.39	24.12	18.84	17.55	12.79
	PCS	19.42	21.11	9.23	15.02	28.95	25.51	13.99	10.75
	Vision	19.30	15.33	9.68	12.37	16.89	12.81	16.00	12.94
	Synergy	27.07	21.46	13.07	14.26	14.49	19.30	20.29	13.45
Dr ID									
LV	GP01	6.65	12.08	27.36	22.80	20.16	17.74	16.62	14.14
	GP06	27.06	7.85	15.09	24.72	22.14	16.77	24.09	18.06
	GP10b	16.41	17.49	3.52	6.06	22.49	18.17	15.35	10.89
	GP12	25.22	21.97	40.26	17.00	35.12	20.73	26.72	11.28
	GP14	5.22	8.98	2.92	4.66	25.35	21.94	11.25	7.95
PCS	GP03	23.25	21.78	5.10	16.80	25.09	24.98	11.02	10.51
	GP10a	15.94	19.97	14.02	16.04	32.16	32.18	12.18	12.11
	GP15	18.54	22.58	10.11	11.93	31.06	24.24	18.96	8.72
Synergy	GP04	37.78	24.48	13.91	13.98	22.73	26.30	15.52	10.79
	GP05	11.72	9.55	11.77	14.09	9.53	12.55	22.67	11.89
	GP08	33.02	16.26	12.76	17.47	10.98	15.39	26.64	18.96
Vision	GP02	9.09	11.04	14.38	13.31	9.36	4.17	13.49	8.46
	GP07	28.73	23.14	3.64	3.18	10.75	13.46	17.38	12.17
	GP09	30.40	13.31	2.50	4.56	19.89	18.20	12.57	9.78
	GP11	16.22	10.00	10.38	13.23	22.49	12.41	17.94	12.53
	GP13	14.81	11.28	14.71	15.55	18.84	10.53	17.94	18.35

Table 9.22: Proportions of the task duration patient was talking to the doctor

		X	SD	M	IQR	Valid N	Sum
Encounter review	**All**	9.46	10.71	6.19	8.18	542	5126.55
	LV	10.66	13.11	7.12	8.81	176	1876.37
	PCS	10.33	10.60	7.24	9.90	89	919.46
	Vision	8.32	9.63	4.83	6.16	189	1572.95
	Synergy	8.61	6.72	6.30	8.91	88	757.77
Examination findings review	**All**	11.23	12.57	7.21	8.43	50	561.58
	LV	15.67	18.76	9.31	6.05	14	219.40
	PCS	8.00	8.94	4.19	5.60	12	95.94
	Vision	3.83	2.02	3.06	1.16	12	45.98
	Synergy	16.69	8.69	14.23	16.81	12	200.26
Test results review	**All**	13.38	12.92	8.55	15.53	73	976.89
	LV	11.17	8.98	7.95	12.32	13	145.18
	PCS	15.47	18.64	7.11	10.02	21	324.83
	Vision	10.21	8.51	7.32	10.36	26	265.43
	Synergy	18.57	11.27	19.82	17.42	13	241.45
Letter reading	**All**	23.97	22.04	17.73	17.50	55	1318.24
	LV	23.27	20.39	18.46	17.80	28	651.64
	PCS	11.48	7.89	13.11	12.32	4	45.90
	Vision	16.12	7.81	15.49	11.48	4	64.48
	Synergy	29.27	27.08	19.12	25.17	19	556.22
BP entry	**All**	12.20	5.06	10.20	5.25	41	500.14
	LV	12.71	6.05	10.16	5.34	15	190.67
	PCS	14.06	3.67	15.19	6.42	8	112.49
	Vision	12.45	5.56	9.72	3.94	8	99.61
	Synergy	9.74	3.44	9.19	5.30	10	97.37
Coded entry	**All**	7.85	5.30	6.53	5.40	349	2740.51
	LV	8.98	6.14	7.25	5.54	87	781.08
	PCS	5.68	3.43	4.70	3.71	59	335.00
	Vision	8.76	5.91	7.13	6.60	113	990.01
	Synergy	7.05	3.95	5.83	5.03	90	634.42
Free text entry	**All**	20.73	23.96	12.90	19.61	515	10675.81
	LV	14.42	11.82	11.25	11.95	250	3603.87
	PCS	27.09	30.74	17.44	25.79	114	3088.73
	Vision	36.71	34.88	28.37	33.69	88	3230.36
	Synergy	11.95	9.60	8.51	11.77	63	752.85
Template use	**All**	16.75	27.40	9.89	9.79	64	1071.71
	LV	12.19	15.23	9.14	7.55	35	426.56
	PCS	12.20	5.88	9.90	8.79	9	109.78
	Vision	63.22	61.82	63.22	87.43	2	126.43
	Synergy	22.72	41.62	12.47	10.46	18	408.94

Table 9.23: Time taken for information reviewing and data entry tasks (in seconds)

		X	SD	M	IQR	Valid N	Sum
Rx review	All	25.50	28.00	13.32	28.44	86	2192.93
	LV	28.56	29.53	21.37	32.11	41	1171.08
	PCS	34.68	34.35	21.46	39.27	17	589.63
	Vision	18.01	21.22	8.84	30.12	18	324.17
	Synergy	10.81	5.32	10.57	7.82	10	108.05
Rx acute	All	452.26	237.37	411.07	312.15	126	56984.61
	LV	417.40	202.57	373.30	266.79	44	18365.53
	PCS	500.08	167.83	477.54	266.68	30	15002.46
	Vision	484.87	334.29	432.08	325.03	32	15515.97
	Synergy	405.03	204.76	410.06	402.21	20	8100.65
Rx issue and print	All	8.16	5.09	6.52	5.32	93	759.12
	LV	9.28	6.36	6.58	7.33	24	222.68
	PCS	8.01	2.75	8.17	3.67	16	128.23
	Vision	9.24	5.44	6.84	7.46	34	314.02
	Synergy	4.96	2.29	4.28	3.28	19	94.19
Rx repeat - new	All	25.08	13.76	20.69	8.03	15	376.25
	LV	21.13	8.91	22.85	12.98	4	84.50
	PCS	.	.	.	.	0	.
	Vision	27.50	15.71	20.79	6.18	10	274.98
	Synergy	16.77	.	16.77	.00	1	16.77
Rx repeat - old	All	13.81	8.35	13.34	12.99	43	593.89
	LV	13.83	7.41	14.26	13.60	24	331.91
	PCS	16.23	11.15	15.72	13.14	5	81.17
	Vision	11.42	5.34	13.02	10.00	9	102.79
	Synergy	15.60	14.49	12.66	10.03	5	78.02
Test requests	All	10.34	18.03	2.71	8.53	112	1157.54
	LV	7.66	15.42	1.65	3.93	20	153.12
	PCS	2.55	3.13	1.25	1.11	18	45.91
	Vision	14.49	21.38	6.49	14.34	61	883.96
	Synergy	5.73	10.76	.89	1.05	13	74.55
Letter writing	All	28.13	34.91	14.97	30.74	36	1012.54
	LV	31.97	28.00	20.68	51.08	11	351.67
	PCS	36.16	53.17	14.32	16.00	11	397.76
	Vision	39.20	15.91	36.55	17.72	5	195.99
	Synergy	7.46	5.16	5.50	8.04	9	67.12
Referral	All	59.85	58.82	37.61	91.64	18	1077.32
	LV	76.14	99.16	34.06	184.45	3	228.41
	PCS	40.04	58.62	6.72	35.32	5	200.21
	Vision	95.41	40.27	97.54	81.35	6	572.46
	Synergy	19.06	9.85	17.60	12.23	4	76.24

Table 9.24: Time taken for taking actions using the EPR system (in seconds)

		$\bar{X}$	SD	M	IQR	Valid N	Sum
Prompt display	**All**	3.29	2.55	2.50	2.00	355	1167.75
	LV	3.12	2.18	2.39	2.26	62	193.73
	PCS	2.93	2.01	2.33	1.35	107	313.05
	Vision	3.63	2.98	2.71	2.47	111	403.28
	Synergy	3.44	2.78	2.56	2.41	75	257.69
System delays-errors	**All**	17.64	26.59	10.69	12.55	52	917.53
	LV	26.50	37.65	12.53	20.32	8	211.98
	PCS	21.15	15.92	17.00	12.78	5	105.76
	Vision	15.78	27.43	8.95	10.28	33	520.61
	Synergy	13.20	5.05	12.11	3.98	6	79.18
Transitions - EPR and external	**All**	6.67	9.11	3.10	3.75	70	467.06
	LV	5.54	7.08	3.55	2.40	25	138.57
	PCS	6.80	5.51	4.27	10.11	3	20.40
	Vision	6.46	9.25	3.00	5.00	22	142.05
	Synergy	8.30	11.66	3.09	6.03	20	166.04
Transitions within EPR	**All**	3.05	2.59	2.36	2.16	2031	6203.49
	LV	2.68	2.01	2.14	1.93	831	2228.79
	PCS	3.35	2.93	2.56	2.88	447	1496.55
	Vision	3.51	3.14	2.57	2.14	472	1657.45
	Synergy	2.92	2.33	2.34	1.73	281	820.70

Table 9.25: Time taken for overhead tasks (in seconds)