Diabetes self-management during the COVID-19 pandemic and its associations with COVID-19 anxiety syndrome, depression, and health anxiety

Running title: Diabetes self-management and COVID-19 anxiety syndrome

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Abstract Word Count: 234

Number of Tables and Figures: 2 + 2

CONFLICT OF INTERESTS

All authors declare no conflicts of interest.

NOVELTY STATEMENT

What is already known?

Anxiety and depression are predictors for suboptimal diabetes self-management and this may have been magnified during the COVID pandemic since people with diabetes were advised that they were at risk.

What has this study found?

Rates of COVID Anxiety Syndrome are not high amongst people with diabetes, however rates of depressive symptoms were much higher than pre-pandemic levels and this was significantly associated with suboptimal diabetes self-care. Conversely, high levels of COVID-19-related avoidant behaviour were associated with improved measures of diabetes self-management.

What are the implications of the study?

As we return to face-to-face clinical encounters, we should be aware of high levels of mental distress amongst people with diabetes.

Author contributions statement

V.S., M.S., W.D., N.O., A.N. and V.M. designed the study, V.S., S.S., M.M., A.A., E.A., D.H, R.S. and K.S. contributed to the execution of the study and data collection, W.D. and V.S. prepared the data analysis, V.S. wrote the manuscript and all authors contributed to the editing of the manuscript. V.S. is the guarantor of this work, had full access to the data, and accepts full responsibility for the integrity of the data and the accuracy of the data analysis.

ABSTRACT

Introduction: The effects of the COVID-19 pandemic on mental health have been profound. Mental health and diabetes self-care are inter-related. We examined whether COVID-19 anxiety, depressive symptoms and health anxiety were associated with domains of diabetes self-management and investigated whether greater COVID-19 anxiety syndrome would independently contribute to suboptimal diabetes self-care.

Research Design and Methods: Surveys were sent to people attending diabetes clinics of three London hospitals. Participants completed the Diabetes Self-Management Questionnaire (DSMQ), the COVID-19 Anxiety Syndrome Scale (C-19 ASS), which measures perseveration and avoidant maladaptive coping behaviour, assessed with measures of co-existent depressive symptoms and anxiety, controlling for age, gender, and social deprivation. Clinical data, including pre- and post-lockdown HbA1c measures, were obtained from hospital records for 369 respondents a response rate of 12.8%.

Results: Depressive symptom scores were high. Both pre-existing health anxiety and depressive symptoms were independently linked to improvable measures of diabetes care, as was lower socioeconomic rank. However, avoidant COVID-19 anxiety responses were independently associated with higher diabetes self-care scores. HbA1c levels improved modestly over the year of UK lockdown in this cohort.

Conclusion: During the height of lockdown, avoidant coping behaviours characteristic of the COVID-19 anxiety syndrome may in fact work to improve diabetes self-care, at least in the short term. We recommend screening for depressive symptoms and being aware of the significant minority of people with COVID-19 anxiety syndrome who may now find it difficult to re-engage with face-to-face clinic opportunities.

INTRODUCTION

Coronavirus disease (COVID-19), caused by the SARS-CoV-2 virus, was declared a pandemic by the World Health Organisation (WHO) on 11th March 2020. By March 2021, there were 115 million confirmed cases and over 2.5 million deaths worldwide. To curb the spread of the virus and protect frontline medical services from becoming overwhelmed, many countries implemented pervasive social distancing measures. "Lockdown" came into place on 26th of March 2020 in the United Kingdom. By July 2021, although there have been transitions between levels of severity, the country had not yet returned to normality of social interactions.

COVID-19 infection carries a poorer prognosis with advancing age and also in those with comorbidities. With a global prevalence of 8.5%, diabetes is second only to hypertension as the most common co-morbidity documented in patients hospitalised with COVID-19.[1,2] Diabetes is an established risk factor for severe COVID-19. The largest scale UK study of 23, 698 in-hospital COVID-19-related deaths reported adjusted odds of mortality for patients with Type 1 and Type 2 diabetes of 2.86 and 1.80 respectively.[3] Accordingly, UK guidelines state that a diagnosis of diabetes confers an increased COVID-19 risk, and during the riskiest phases of the pandemic, enhanced precautions and shielding measures were recommended for these individuals.[4]

Social distancing measures were proven to prevent deaths,[5] however the implementation of lockdown has had a significant impact on mental health. In the UK general population during the first phase of the pandemic, 22.1% of surveyed people had symptoms of moderate/severe depression, and 21.6% of moderate/severe anxiety,[6] proportions higher than pre-pandemic estimates of 17.0% and 13.0% respectively.[7] Fear and anxiety related to COVID-19 have also been reported[8] as well as a specific pattern of coping in relation to the threat of COVID-19 infection, termed the "COVID-19 anxiety syndrome".[9] A scale, the COVID-19 Anxiety

Syndrome Scale (C-19 ASS), enables the assessment of COVID-19-related avoidance, checking, worrying and threat monitoring, which has been found to predict generalised anxiety and depressive symptoms independently of age, gender, employment and risk status, personality traits and health anxiety in both US and UK community samples.[9-11]

There is a complex bi-directional relationship between symptoms of mental health and diabetes self-care. Amongst people with diabetes, depressive symptoms were associated with lower diabetes self-care (as measured by the Diabetes Self-management Questionnaire, DSMQ), and indirectly with higher HbA1c.[12] Given the possible interplay between COVID-19 susceptibility, maladaptive responses to the fear of COVID-19, depressive symptoms, anxiety, and self-care in people with diabetes, clinicians managing these individuals need a better understanding of their needs as lockdown restrictions ease and clinical re-engagement occurs.

With that goal in mind, people with diabetes on outpatient clinic lists across three London hospitals were surveyed during the second major lockdown (January to March 2021) and how COVID-19 anxiety syndrome, depressive symptoms and health anxiety linked to domains of diabetes self-management, as measured by the DSMQ, was examined, whilst controlling for age, gender, and social deprivation. Whether greater COVID-19 anxiety syndrome prevalence would independently contribute to suboptimal diabetes self-care was investigated.

METHODS

Study setting

All people on clinic lists in 2019 attending the Diabetes Service at Imperial College Healthcare NHS Trust (ICHNT), which includes three London hospitals (Charing Cross Hospital, Hammersmith Hospital and St Mary's Hospital) were invited via email (using a secure Qualtrics link) or, if no email address was on file, a postal pack to return their study surveys. Study participants had to confirm that they had read the information leaflet and signed informed consent for their responses to be included. The survey was open between 7th January and 2nd March 2021. This study was approved by the Frenchay Research Ethics (REC reference 20/PR/0771).

Data Collection

Participants were sent a request to fill in the following 5 questionnaires.

The Diabetes Self-Management Questionnaire (DSMQ)

To measure diabetes self-management, participants received the validated 16-item DSMQ, which assesses five domains using a four-point Likert scale (e.g. 0 for "does not apply to me at all" through to 3 for "applies to me very much"): 'dietary control' (DSMQ-DC), glucose monitoring (DSMQ-GM), 'medication adherence' (DSMQ-MA), physical activity (DSMQ-PA) and physician contact (DSMQ-PC).[13] Both DSMQ sub-scores and the cumulative score (DSMQ-total) are calculated, with higher scores reflecting more optimal diabetes self-care. The DSMQ has been validated for use in people with Type 1 and Type 2 diabetes.[13,14] Where questions are not answerable (for example, if they relate to insulin dosing in people who do not inject), the score can be rescaled. A scaled DSMQ score was therefore calculated as actual sum of items/maximum possible sum of items x10. The transformed scale score can vary between 0 and 10.

The COVID-19 Anxiety Syndrome Scale (C-19 ASS)

The C-19 ASS is a 9-item survey which assesses COVID-19 anxiety-related maladaptive coping behaviour, with two domains of perseveration (excessive symptom checking, worrying and threat monitoring) and avoidance. Participants rank their responses using a 5-point Likert scale (0-4 points). Total scores range from 0-36, with higher scores indicating greater COVID-19 anxiety syndrome severity.

7-item Whiteley Index (WI-7)

To account for pre-existing health anxiety, the WI-7 was used. Participants respond using a 5-point Likert scale: 'Not at all' to 'Great deal' (0-4 points). Total scores range between 0-28, with a score >21 suggestive of clinically relevant health anxiety.[15]

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 has been extensively used in studies evaluating depressive symptoms in people with diabetes. Participants answer using a 4-point Likert scale: 'Not at all' to 'Nearly every day' (0-3 points). Higher PHQ-9 scores indicate progressively increasing depressive symptom severity, and a score $\geq$ 10 has 88% sensitivity and 88% specificity for depressive disorder.[16]

Clinical Data

No demographic or clinical data were requested via self-reporting. Instead, the questionnaires had a code linking researchers to that respondent's unique hospital number and clinical data were collected from electronic health records held on the ICHNT computer system (Cerner Corporation, Kansas City, USA).

For all respondents, demographics (age, sex, ethnicity and 2019 Index of Multiple Deprivation rank; IMDR - a higher number indicating greater social deprivation on a scale of 1 – 32, 844), anthropometrics (weight and body mass index), diabetes type and duration, treatment

information (medications for diabetes but also all others e.g. antidepressants), relevant complications (microvascular: retinopathy, neuropathy, nephropathy and macrovascular: cardiovascular disease/stroke) and laboratory data [glycated haemoglobin (HbA1c), estimated glomerular filtration rate (eGFR), total cholesterol: HDL ratio and albumin: creatinine ratio (ACR)] were recorded. For each biochemical parameter, the soonest measurement before (pre-COVID) and the latest after December 2019 was obtained to identify trends over the pandemic. Data points were more than 3 months and less than 18 months apart as a minimum and maximum.

Statistical Analysis

Mean and standard deviation (SD) were used to summarise continuous variables and mean and interquartile range (IQR) used to summarise ordinal and non-Gaussian variables. Distribution was assessed using the Shapiro-Wilk test. Where data were continuous and followed a Gaussian distribution, p-values were calculated using either the two-tailed t-test (paired or unpaired) or the one-way ANOVA (Tukey's multiple comparisons test was used for post hoc analysis). Where data were ordinal or of non-Gaussian distribution, comparators used were the Mann-Whitney U test for unpaired data or the Wilcoxon signed-rank test for paired data. Categorical values are summarised as a percentage and a chi-squared test was used for comparison. To identify univariate associations, correlation matrices were calculated using two-tailed Spearman's rank. These univariate and group comparison analyses were performed using GraphPad Prism, Version 9. An a priori power calculation, based on the requirement of 20 participants per questionnaire factor, provided the aim of a minimum of 180 responses from people with diabetes.

To uncover the independent determinants of suboptimal self-care (low DSMQ scores) a proportional odds model was estimated in Matlab. Since the dependent variables (DSMQ factors) are ordinal scores with bounded support, DSMQ scores were divided into three categories: 'Low', 'Medium' and 'High'. The threshold values to determine which category a given person fits into reflect the cross-sectional distribution of the score. Hence, the bottom 30% of the sample were included in the 'Low' category, the mid 30% in the 'Medium' category, and the upper 40% in the 'High' one.

The estimated functional form is explained in the equations:

$$\log\left(\frac{Pr('Low')}{Pr('Medium'\ or\ 'High')}\right) = I_1 + X^T\beta;$$

$$\log\left(\frac{Pr('Low'\,or\,'Medium')}{Pr('High')}\right) = I_2 + X^T\beta$$

where X is a matrix containing the potential determinants of the score, and β is a vector of parameters to be estimated by maximum likelihood of predicting low self-care. Therefore, since this was modelled with 'low' DSMQ score as the numerator, when a variable has a positive β coefficient it should be interpreted to mean that as the variable increases, there is a greater chance of a lower (suboptimal) DSMQ score. Conversely, a negative β coefficient means that as that variable increases it is independently associated with a higher (better) DSMQ score. The choice of the variable to include in X was informed by previous literature, but also by data quality issues. For this reason, ethnicity, which was poorly recorded in the hospital notes, was not included in the analysis.

RESULTS

Invitations to participate in the study were sent out to 2, 894 people, of whom 59% were women and 64% had Type 1 diabetes. 369 people with diabetes successfully completed the study, a response rate of 12.8%. Characteristics of the respondents are presented in **Table 1**. The average age was 50.5 ± 16.0 years (compared with a mean age of 51.6 years for all those written to). Respondents were well gender-balanced (women: 52.9 %) and most had been diagnosed with Type 1 diabetes (70.5%). Although only 7.9% of respondents for whom ethnicity data was retrievable were from minority ethnic populations, 54.2% of participants had missing ethnicity data. Socioeconomic deprivation and previous severe COVID-19 disease necessitating hospital management were uncommon in this group.

The range of questionnaire scores (C-19 ASS, DSMQ, WI-7 and PHQ-9) for the whole cohort, and divided by type of diabetes, are given in **Table 1**. Respondents with diabetes had a smooth distribution of health anxiety scores, weighted towards lower levels (**Figure 1a**). Similar distribution plots of C-19 ASS results (avoidance and perseveration sub-scores) are presented in **Figures 1c** and **1d**. These distributions point to a small group of participants with very high C-19 ASS scores. DSMQ scaled scores, expressed as a total (DSMQ-total) and five sub-scores, which reflect the different aspects of diabetes self-care, revealed highest self-assessed scores for glucose monitoring and lowest scores for physical activity in this cohort. However, overall, only 4% of participants with Type 1 diabetes and 18% of participants with Type 2 diabetes reported a scaled DSMQ score >6, a commonly used cut-off to assign "good" diabetes self-management.[12,13]

To examine the univariate associations between the mental health questionnaires, diabetes disease self-management (as measured with the DSMQ) and demographic factors, a correlation matrix is presented in **Figure 2**. In survey respondents with diabetes of any type, C-19 ASS

scores were associated with WI-7 (R=0.32 each for perseveration and for avoidance, p<0.0001) and PHQ-9 (R=0.22 for both perseveration and for avoidance, p<0.0001), suggesting symptoms of health anxiety and depression are likely to occur alongside COVID-19 anxiety syndrome in people with diabetes. WI-7 and PHQ-9 were both negatively associated with all aspects of DSMQ (R = -0.33 and -0.45, p<0.0001 for DSMQ-total), confirming the expected association of anxiety and depressive symptoms with improvable reported measures of diabetes self-care. Total scores on the DSMQ were not significantly associated with either the perseveration or the avoidance component of the COVID-19 anxiety syndrome.

A multivariate proportional odds analysis was then performed to better understand the marginal associations with the different factors within the DSMQ (**Table 2**). Of note, women gender and age were not found to be independently associated with differences in DSMQ. However, greater socioeconomic deprivation was significantly related to suboptimal diabetes self-management: the effect size was small for each division but over a scale of 32, 844 divisions, this was a major contributor: moving from the most to the least deprived score on the scale was associated with a 33% increased probability of achieving a high (versus a medium or low) self-management score. Surviving correction for the other measured variables, both depressive symptoms and health anxiety remained independently and significantly associated with lower DSMQ-total and physician contact scores. Depressive symptoms were also associated with reduced 'dietary control' and 'medication adherence'. Conversely, higher C-19 ASS avoidance scores were linked to higher self-management scores, shown by a negative association with low DSMQ global (p=0.021) and more physician contact (p=0.026). Higher perseveration scores of the C-19 ASS were associated with less physician contact, similar to general heath anxiety.

To determine whether these questionnaire-based findings aligned with clinical measures of diabetes management, paired clinical data before and during the COVID-19 pandemic was

analysed. Despite high scores on average for depressive symptoms in this cohort at the height of the UK's second lockdown, a small but significant improvement in mean HbA1c levels compared with paired pre-pandemic values was found. Data for 86 of the respondents was available providing a paired pre- and post- lockdown HbA1c comparison no more than 18 months apart. Average HbA1C in that group fell from 62.13 to 60.16 mmol/mmol (p=0.0033). No significant differences were observed in other clinical markers.

DISCUSSION

This study sought to record levels of COVID-19-related anxiety during the second UK lockdown, between January to March 2021, and to link these with measures of diabetes self-management in people listed in diabetes clinics at three London hospitals. For over half of respondents, C-19 ASS scores suggested high levels of COVID-19 anxiety syndrome which is consistent with the UK general population.[11] The response rate was lower than other community mental health surveys at only 12.8% and of course it is difficult to infer whether this in itself reflects a bias towards those who felt that COVID-related anxiety was a pertinent issue for them. Whilst COVID-19 anxiety syndrome has been found to be associated with generalised health anxiety, the high levels of COVID-19 anxiety syndrome in this cohort were not driven by somatoform disorder, with less than 6% reporting WI-7 scores above the cut-off for significant health anxiety. However, over a quarter of respondents reported PHQ-9 scores suggestive of clinically relevant depressive symptoms. Pre-pandemic estimates of depression or depressive symptoms' prevalence in the UK and Europe are about 20-25%.[17,18] Rates of depressive symptoms reported in the general population in the UK during the pandemic range from 22-30%.[6,19] Thus, whilst others have reported a disproportionate deterioration in mental health in people with diabetes, assumed to be because of additional fears about higher COVID-19 infection risks or the pre-existing interplay between diabetes and depression or depressive symptoms[20-22] and although rates of depressive symptoms and COVID-19 anxiety syndrome were very high due to lockdown, comorbid diabetes was not associated with even greater susceptibility to psychological distress in this population.

Although there is no direct comparison with pre-pandemic scores for this cohort, DSMQ scores in this study point to self-perception of improvable diabetes management at the height of lockdown, which is supported by other studies reporting a deterioration in self-care in people with diabetes during the pandemic.[23-26] In contrast, other studies have shown that people with

diabetes have been maintaining better diabetes management during this period.[27,28] At the outset, we hypothesised that COVID-19 anxiety syndrome might negatively impact on diabetes self-care. Indeed, C-19 ASS perseveration sub-scores were associated with less physician contact, similar to health anxiety. It could be that people exhibiting more checking, worrying and threat monitoring in relation to COVID-19 experienced more threat and fear during the pandemic which in turn motivated them to seek doctors' advice and attend regular doctors' appointments. A similar pattern was observed in those with greater health anxiety. However, contrary to predictions, higher C-19 ASS avoidance sub-scores were linked to better diabetes self-management efficacy in this cohort. In other words, higher scores related to COVID-19 avoidant (self-protective) behaviour were independently and significantly associated with higher scores of diabetes self-management and more physician contact. This fits with the notion that those who are more engaged with looking after their health were less likely to risk opportunities for infection e.g. using public transport. Avoidant behaviour may also lend itself to staying at home (physical activity scores were particularly low in this group) and therefore finding it easier to maintain scheduled eating times, more predictable routines, or other favourable aspects of self-care. In line with this, despite participants perceiving suboptimal diabetes self-care scores during the pandemic and quite high levels of depressive symptoms, HbA1c levels actually improved. However, the average improvement was small and the longevity of this effect remains to be seen, casting doubt on the actual clinical significance of this observation. It is possible that during enforced lockdown, diabetes management may have been seen as an effective method to reduce the risk of COVID-19 susceptibility. Further research will need to ascertain the relevance of C-19 ASS avoidance, particularly as the transition back to greater face-to-face interaction could induce anxiety in those who were particularly avoidant.

There are some limitations in this study that should be considered when interpreting its findings. It is becoming less commonplace to perform studies on cohorts of patients with both Type 1 and Type 2 diabetes, given the differences in the management, lived experience and self-care challenges across the conditions. Outcomes from respondents with Type 1 and Type 2 were combined here however, partly to ensure coverage of all of the clinic cohort and the exigencies of understanding the impact of the pandemic on patients' self-care. Nevertheless, differences in the way in which patients with Type 1 and Type 2 diabetes may experience elements that are measured in the DSMQ (although validated for both conditions) should be borne in mind when interpreting the data presented[29] . Direct comparisons with pre-pandemic figures for this particular cohort cannot be made. With a large proportion of respondents identifying as White (which is not demographically representative of the actual patient population[30]) and with HbA1c levels in this cohort lower than previous measurements of the London average for people with diabetes,[31] our findings should not be broadly generalised[32]. It is possible that the salience of the study at a time of great challenge due to COVID may have encouraged some to reply; conversely patients with diabetes also suffering symptoms of mental illness may be less motivated to engage with a survey received by post/email, a key factor for survey non-response.[32,33] For example, the Community Mental Health Survey often has one of the lowest response rates in the NHS's Patient Survey Programme, a programme that seeks patients feedback on the healthcare they receive across England.[34] Aligned with this is the clear result on multivariate analysis of the continued independent association of socioeconomic deprivation and diabetes self-care – another reminder of the need to address inequalities in the health service.

Finally, this study was open for the early months of 2021. During that time, the UK had only just started to roll out its vaccination programme and by the time this study had closed, only frontline health care workers or those aged over 80 years had at large-scale received a vaccine

dose. It is therefore unlikely that the security of immunity was a confounder in the responses gathered, although the survey did not ask if participants believed that they had already caught and recovered from COVID-19.

In summary, high levels of depressive symptoms and COVID-19 anxiety syndrome were found in participants. There was an expected significant association between low mood and suboptimal self-management of aspects of diabetes care. During the height of lockdown, avoidant coping behaviours characteristic of the COVID-19 anxiety syndrome may in fact work to improve diabetes self-care, at least in the short term. We recommend screening for depressive symptoms as people return, in person, to diabetes clinics and monitoring for the potential longer-term ramifications on diabetes self-management as we discover the post-pandemic "new normal". We should also be aware of the significant minority of people with COVID-19 anxiety syndrome who may now find it difficult to re-engage with face-to-face clinic opportunities.

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FIGURE LEGENDS

Figure 1: Probability distribution plots for (1a) Whiteley-7 scores (empirical frequencies), (1b) Whiteley-7 scores (cumulative frequencies), (1c) C-19 ASS Avoidance and (1d) C-19 ASS Perseveration scores in survey respondents with diabetes.

Figure 2: Univariate correlation table (Spearman rank coefficient) between different measured factors in participants with diabetes who responded to the email/postal survey of mental health and diabetes self-management questionnaires during the second UK lockdown (January to March 2021; n=369). Stars indicate correlations that reached significance when corrected for using Bonferroni's correction for multiple testing (p<0.00385). Blank white squares indicate an R value of 0 to 2sf.

Abbreviations: C-19 ASS A = COVID-19 Anxiety Syndrome Scale Avoidance sub-score, C-19 ASS P = COVID-19 Anxiety Syndrome Scale Perseveration sub-score, DSMQ = Diabetes Self-Management Questionnaire, PHQ-9 = Patient Health Questionnaire-9, WI-7 = Whiteley Index-7, IMDR = Index of Multiple Deprivation Rank.

TABLES

Table 1: Characteristics of patients attending a London hospital diabetes clinic that responded to a survey of mental health and diabetes self-management questionnaires during the second UK lockdown (January and February 2021).

		Total (n=369)	Type 1 Diabetes (n=260)	Type 2 Diabetes (n=109)
Demographic Data				
Age, mean (SD)		50.5 (16.0)	45.4 (16.3)	57.8 (12.3)
Gender	Men %	47.1%	44.8%	50.5%
	Women %	52.9%	55.2%	49.5%
Ethnicity, n (% total cohort)	White Caucasian	140 (37.9%)	89 (34.1%)	51 (47.2%)
	Asian / Mixed	22 (6.0%)	8 (3.1%)	14 (13.0%)
	Black / Afro-Caribbean	7 (1.9%)	2 (0.8%)	5 (4.6%)
	Not specified	200 (54.2%)	161 (62.1%)	39 (35.2%)
Index of Multiple Deprivation Rank*, n	Bottom tertile	85 (26.0%)	52 (24%)	35 (32%)
	Middle tertile	129 (39.7%)	86 (40%)	37 (34%)
	Top tertile	111 (34.3%)	78 (36%)	37 (34%)
	Not specified, n	44	44	0
Clinical Data				
Diabetes Duration, years; mean $\pm$ SD (number of respondents data available for)		17.0 $\pm$ 13.7 (225)	21.8$\pm$14.6 (130)	10.3$\pm$8.8 (95)
Most recent weight, kg; mean $\pm$ SD (number of respondents data available for)		85.0 $\pm$ 23.9 (213)	78.1 $\pm$ 16.5 (118)	93.5 $\pm$ 27.0 (95)
ICHNT COVID Admission, n (% total cohort)		4 (1%)	1 (0.4%)	3 (2.8%)

ICU Admissions, n (% total cohort)		1 (0.25%)	1 (0.4%)	0 (0%)
Treatment Data				
Insulin use, % total cohort			100%	42%
Oral Hypoglycaemic medication only, n (%)	Total		4.2%	78.9%
	Metformin only		4.2%	30.3%
	Multiple oral hypoglycaemic use		0%	48.6%
Previous bariatric surgery			0	5.5%
Anti-depressant/anxiolytic use, % total cohort			11.2%	8.4%
Complication Data				
Retinopathy			46.9%	19.2%
Neuropathy			21.3%	21.1%
Advanced Nephropathy			8.4%	15.6%
Cardiovascular disease			9.1%	11.0%
C-19 ASS scores				
C-19 ASS total mean score (IQR) **(max score 36, scores >18 suggestive of COVID anxiety syndrome)**		18.22 (11-25)	18.15 (21-25)	18.39 (11-26)
C-19 ASS P perseveration sub-score: mean score (IQR)		10.52 (6-15)	10.47 (6-15)	10.63 (6-16)
C-19 ASS A avoidance sub-score: mean score (IQR)		7.70 (4-11)	7.68 (4-11)	7.75 (4-12)
DSMQ scores (scaled): max score 10, scores>6 suggest good self-care				
DSMQ total: mean score (IQR)		4.14 (3-4)	4.07 (4-4)	4.62 (4-5)
% with a mean DSMQ-total score >6			4%	18%
DSMQ-PC: mean score (IQR)		4.02 (3-4)	3.37 (3-4)	4.43 (3-6)
DSMQ-GM: mean score (IQR)		5.40 (5-6)	5.41 (7-9)	5.47 (5-6)
DSMQ-PA: mean score (IQR)		2.51 (2-3)	2.51 (3-4)	3.55 (2-4)
DSMQ-DC: mean score (IQR)		4.21 (3-5)	4.21 (3-5)	4.49 (3-5)
Whiteley-7 scores: max score 28, scores>21 suggest significant health anxiety				
WI-7 total: mean score (IQR)		9.87 (5-14)	9.68 (5-13)	10.31 (5-14)

% with a score≥21 (indicating clinically significant health anxiety)	5.5%	5.4%	5.5%
PHQ-9 scores: max score 27, scores>10 suggest clinically significant depressive symptoms			
PHQ-9 total: mean score (IQR)	7.28 (2-10)	7.03 (2-10)	7.86 (3-12)
% with a score≥10 (indicating clinically moderate to severe depressive symptoms)	27.6%	26.5%	28.4%

Table 1: Characteristics of all participants with Type 1 Diabetes (n=260) and Type 2 Diabetes (n=109) who usually attend hospital diabetes clinics and responded to our email/postal survey of mental health and diabetes self-management questionnaires during the second UK lockdown (January and February 2021). Clinical data was accessed from CERNER patient database. * Index of Multiple Deprivation (IMD) ranks every small area in England from 1 (most deprived area) to 32, 844 (least deprived area) based on 7 domains, such as employment levels, gathered by the UK Ministry of Housing each year. *Abbreviations – SD: Standard Deviation, kg: kilogram, ICHNT: Imperial College Healthcare NHS Trust, ICU: Intensive Care Unit, C-19 ASS: Covid-19 Anxiety Syndrome Scale, IQR: Interquartile Range, DSMQ: Diabetes Self-Management Questionnaire (domains – PC: Physician Contact, GM; Glucose Monitoring, PA: Physical Activity, DC: Dietary Control), WI-7: 7-item Whiteley Index, PHQ-9: Patient Health Questionnaire-9*

Table 2: Factors associated with impaired diabetes self-management

Regressors	DSMQ global β	DSMQ global p-value	Diet control β	Diet control p-value	Physical activity β	Physical activity p-value	Physician contact β	Physician contact p-value	Glucose monitoring β	Glucose monitoring p-value
Intercept 1	-0.482	0.784	1.694	0.332	-1.592	0.384	0.482	0.772	-0.123	0.942
Intercept 2	0.490	0.781	2.858	0.103	-0.500	0.784	1.686	0.311	0.933	0.577
C-19-ASS-A	-0.112	0.021	-0.034	0.482	0.036	0.443	-0.103	0.026	-0.042	0.352
C-19-ASS-P	0.046	0.098	-0.011	0.693	-0.021	0.441	0.093	0.001	0.016	0.558
WI-7	0.067	0.028	0.054	0.075	0.045	0.129	0.093	0.002	-0.036	0.221
PHQ-9	0.130	0.001	0.135	0.001	0.106	0.007	0.121	0.001	0.013	0.720
Women	0.238	0.826	-0.672	0.528	1.276	0.273	-1.107	0.271	1.282	0.231
Age	-0.007	0.694	-0.018	0.304	0.036	0.064	-0.025	0.130	-0.010	0.584
Index of Multiple Deprivation	4.04×10^{-5}	0.038	3.05×10^{-5}	0.123	1.56×10^{-5}	0.419	1.30×10^{-5}	0.483	2.99×10^{-5}	0.112
Type 1 Diabetes	-0.623	0.256	-0.096	0.859	0.488	0.447	-0.251	0.639	-0.507	0.371
Type 2 Diabetes	0.207	0.714	-0.797	0.174	1.543	0.019	-0.276	0.618	1.424	0.016
Psychiatric medication use	0.685	0.192	1.402	0.006	0.364	0.463	-1.432	0.009	0.324	0.516
Cardiovascular disease presence	-0.385	0.481	-0.911	0.120	-0.542	0.296	0.192	0.709	0.276	0.593
Number of microvascular complications	0.170	0.289	-0.101	0.549	-0.023	0.881	0.374	0.017	0.101	0.498

Table 2: Multivariate Regression Analysis using a proportional odds model to identify independent associations of impaired diabetes self-management in all participants with diabetes (n=314 included for whom dataset was complete). Participants were stratified based on DSMQ scores relative to the entire sample: low DSMQ (bottom 30%), middle DSMQ (mid 30%) and high DSMQ scores (upper 40%). To identify the main determinants of impaired diabetes self-management, we used the "low DSMQ score group" as the dependent variable. Therefore, a positive regression estimate indicates that the variable is

associated with worse diabetes self-care and vice-versa. In the case of missing values, data in that row was not analysed (55 participants had missing data and thus were excluded). P<0.05 was considered statistically significant. *Abbreviations – C-19 ASS: Covid-19 Anxiety Syndrome Scale (sub-scores – A: avoidance, P: perseveration), WI-7: 7-item Whiteley Index, PHQ-9: Patient Health Questionnaire-9, DSMQ: Diabetes Self-Management Questionnaire*

1a: Smoothed empirical frequencies of Whiteley-7 Health Anxiety scores in survey respondents with diabetes
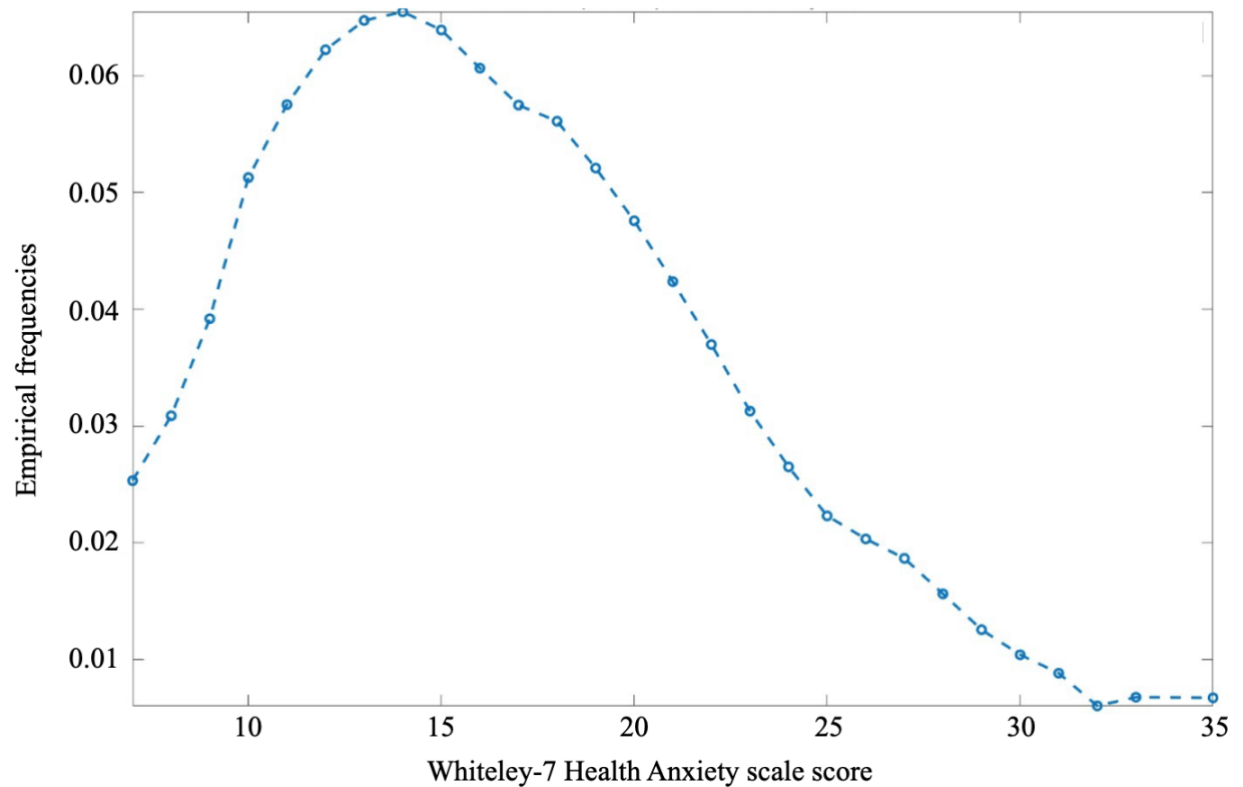
1b: Smoothed cumulative frequency of Whiteley-7 Health Anxiety scores in survey respondents with diabetes
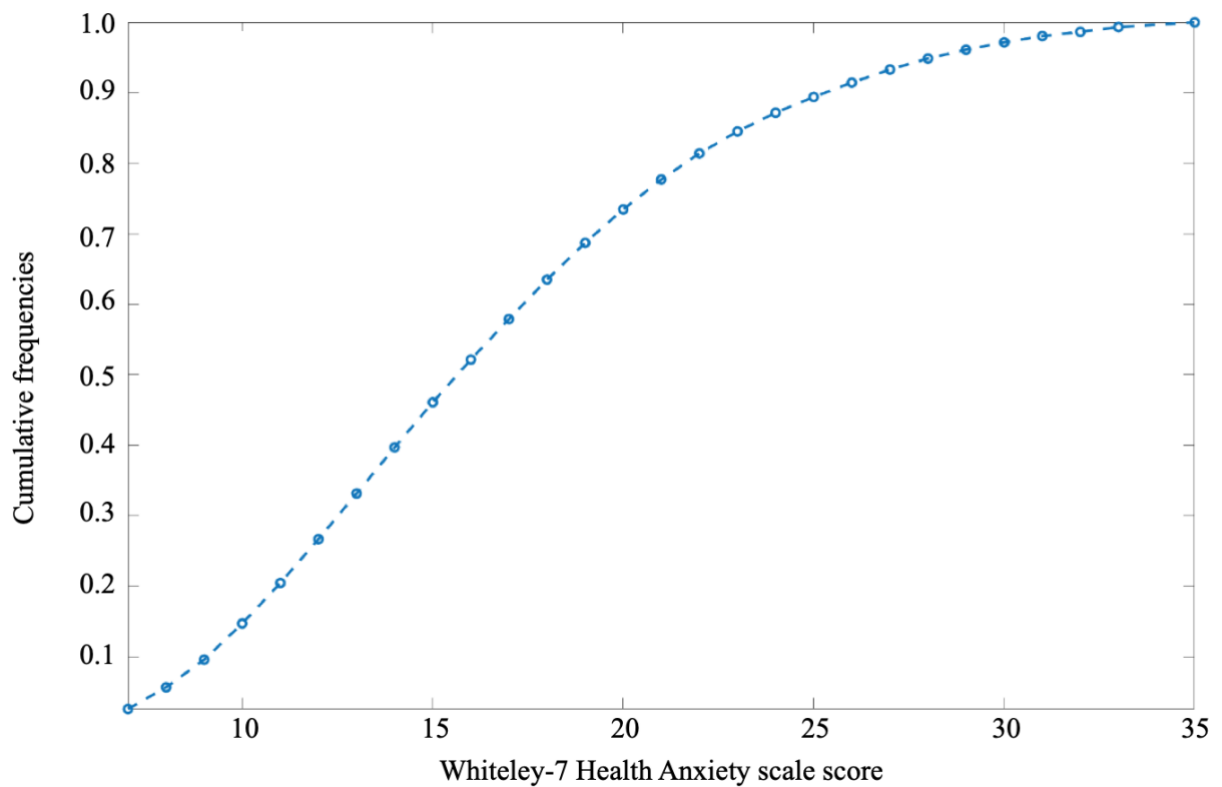
1c: Smoothed empirical frequencies of C-19 ASS Avoidance scores in survey respondents with diabetes
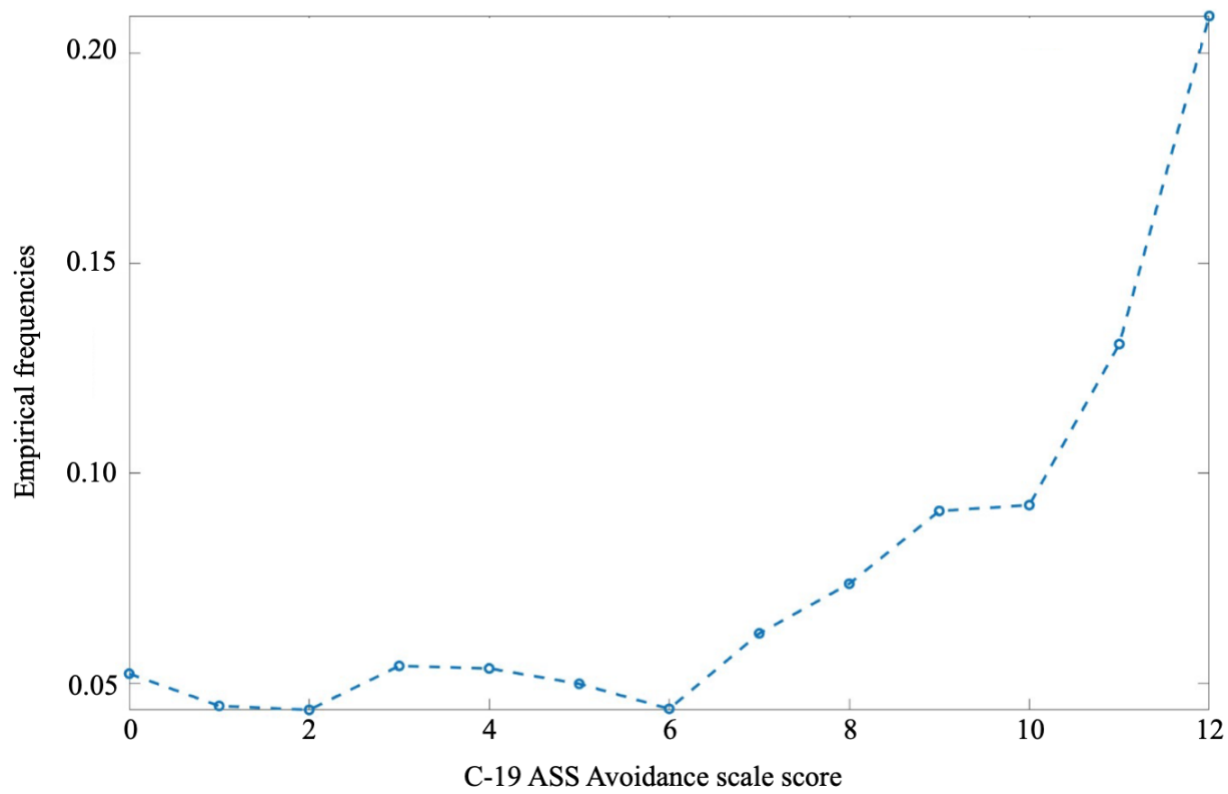
1d: Smoothed empirical frequencies of C-19 ASS Perseveration scores in survey respondents with diabetes
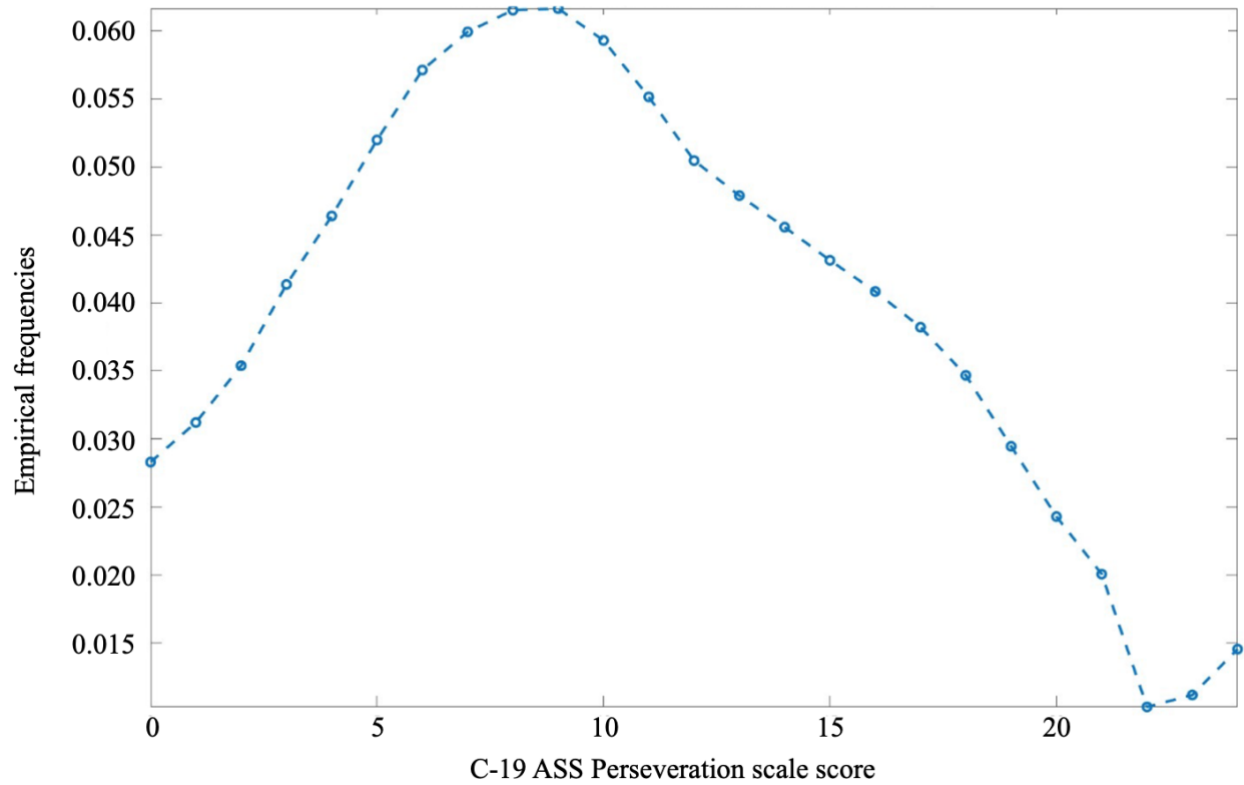
Figure 2

	C-19 ASS total	C-19 ASS A	C-19 ASS P	WI-7	PHQ-9	DSMQ global	Dietary control	Glucose management	Physical activity	Physician contact	Age	Diabetic complications (n)	Index of deprivation
C-19 ASS total	1.00	0.75*	0.92*	0.36*	0.25*	-0.06	0.01	0.01	-0.10	-0.13	-0.07	-0.05	-0.06
C-19 ASS A	0.75*	1.00	0.47*	0.32*	0.22*	-0.03	0.03	0.05	-0.15	-0.04			
C-19 ASS P	0.92*	0.47*	1.00	0.32*	0.22*	-0.04	0.01	0.03	-0.06	-0.15	-0.08	-0.07	-0.08
WI-7	0.36*	0.32*	0.32*	1.00	0.53*	-0.33*	-0.22*	-0.11	-0.28*	-0.30*	0.01	0.07	-0.04
PHQ-9	0.25*	0.22*	0.22*	0.53*	1.00	-0.46*	-0.36*	-0.28*	-0.34*	-0.27*	-0.14	0.04	-0.05
DSMQ global	-0.06	-0.03	-0.04	-0.33*	-0.46*	1.00	0.78*	0.69*	0.63*	0.45*	0.11	-0.08	0.10
Dietary control	0.01	0.03	0.01	-0.22*	-0.36*	0.78*	1.00	0.36*	0.31*	0.22*	0.25*		0.04
Glucose management	0.01	0.05	0.03	-0.11	-0.28*	0.69*	0.36*	1.00	0.24*	0.25*	0.04	0.03	
Physical activity	-0.10	-0.15*	-0.06	-0.28*	-0.34*	0.63*	0.31*	0.24*	1.00	0.18*	-0.14	-0.09	0.08
Physician contact	-0.13	-0.04	-0.15	-0.30*	-0.27*	0.45*	0.22*	0.25*	0.18	1.00	0.10	-0.15	0.13
Age	-0.07		-0.08	0.01	-0.14	0.11	0.25*	0.04	-0.14	0.10	1.00	0.27*	0.15
Diabetic complications (n)	-0.05		-0.07	0.07	0.04	-0.08		0.03	-0.09	-0.15	0.27*	1.00	-0.03
Index of deprivation	-0.06		-0.08	-0.04	-0.05	0.10	0.04		0.08	0.13	0.15	-0.03	1.00