Cross-sectional analysis to explore the awareness, attitudes and actions of UK adults at high risk of severe illness from COVID-19

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ABSTRACT

Objectives This study explored the impact of COVID-19 on people identified as at high risk of severe illness by UK government, and in particular, the impact of lockdown on access to healthcare, medications and use of technological platforms.

Design Online survey methodology.

Setting UK.

Participants 1038 UK adults were recruited who were either identified by UK government as at high risk of severe illness from COVID-19 or self-identified as at high risk with acute or other chronic health conditions not included in the UK government list. Participants were recruited through social media advertisements, health charities and patient organisations.

Main outcomes measures The awareness, attitudes and actions survey which explores the impact of COVID-19, on including access to healthcare, use of technology for health condition management, mental health, depression, well-being and lifestyle behaviours.

Results Nearly half of the sample (44.5%) reported that their mental health had worsened during the COVID-19 lockdown. Management of health conditions changed including access to medications (28.5%) and delayed surgery (11.9%), with nearly half of the sample using telephone care (45.5%). Artificial Intelligence identified that participants in the negative cluster had higher neuroticism, insecurity and negative sentiment. Participants in this cluster reported more negative impacts on lifestyle behaviours, higher depression and longer well-being, alongside lower satisfaction with platforms to deliver healthcare.

Conclusions This study provides novel evidence of the impact of COVID-19 on people identified as at high risk of severe illness. These findings should be considered by policy-makers and healthcare professionals to avoid unintended consequences of continued restrictions and future pandemic responses.

INTRODUCTION

On 11 March 2020, WHO announced that COVID-19 was a global pandemic. In response, governments across the world took a range of actions to help reduce its spread including the development of legislation and policies. The majority of countries also imposed a period of a variable degree of ‘lockdown’.

Beyond the population-level lockdown, further guidance was issued for people identified as at a higher risk of morbidity and mortality from COVID-19. This ‘high-risk’ grouping was typically composed of people living with chronic health conditions such as diabetes, heart disease or AIDS, as well as people who are pregnant or aged 60 years or over. For some 2.2 million people, this additional guidance included the need to ‘shield’ for people identified as the most vulnerable to COVID-19 infection and illness. However, unintended consequences have been noted in emerging evidence, including accentuated feelings of social isolation, self-stigma and loneliness. Thus far, the impact of lockdown and associated restrictions have primarily been reported within the general population, however, given the greater restrictions...
on people identified as at higher risk including a longer duration of lockdown and need to ‘shield’ or self-isolate, the potential impact of COVID-19 is likely to have been greater on this subgroup of the population. Recently, the Office of National Statistics\(^5\) reported that a high proportion of people identified as being at high-risk self-reported that they followed the shielding guidance completely during lockdown.

There is a pressing need to investigate the impact of lockdown and shielding on people identified as at higher risk of severe illness from COVID-19. We defined impact as changes as a consequence of shielding to different aspects of everyday life, including actions and attitudes, healthcare delivery, mental health and well-being, lifestyle behaviours and social interaction. Some of these aspects such as access to healthcare delivery, have not been investigated for this population previously. In terms of attitudes and actions (AAA), emerging evidence from the USA suggests that despite concerns about infection, there was a lack of critical knowledge and limited changes to the plans or routines for people identified as at high risk of severe illness from COVID-19 infection.\(^5\)

Therefore, to understand the impact, and contribute evidence for healthcare policy and networks to support people effectively and address unmet needs, we have delivered a time-sensitive study of the impact the COVID-19 pandemic and the associated UK government guidance has had on people identified as at high risk of severe illness from COVID-19. Specifically, we explored the impact of the COVID-19 lockdown on access to healthcare, health and lifestyle behaviours, and mental health among UK adults identified as at high risk of severe illness from COVID-19.

METHODS

Design

Between 15 March and 31 May 2020, the Awareness, AAA survey was disseminated via UK charities, healthcare and relevant higher education email distribution lists, social media and website advertisement. The survey was hosted by Qualtrics; a third-party online survey administration platform. Inclusion criteria were being aged \(\geq\) 18 years with one or more of the factors for high risk of severe illness from COVID-19 identified by the UK government or self-identified as at high risk due to an acute or chronic health condition not listed.\(^6\)

AAA survey

An online survey was developed to explore the AAA of UK adults identified as at high risk of severe illness from COVID-19 by the UK government or self-identified as high risk. The survey comprised seven sections using a combination of closed and open questions:
1. Participant demographics.
2. Awareness, AAA relating to COVID-19 including whether participants had been diagnosed with COVID-19, experienced symptoms, and took actions to reduce infection and spread.
3. Impact of COVID-19 on management of health conditions and use of technology.
4. Impact on mental health and wellbeing, and depression including the Warwick-Edinburgh Mental Well-being Scale (WEMWBS)\(^7\) and Patient Health Questionnaire (PHQ-9).\(^8\)
5. Lifestyle-related behaviours; diet, alcohol intake, physical activity type and amount, sleep quality and amount, smoking behaviour, e-cigarette use and recreational drug use.
6. Interaction with others regarding changes in other people’s behaviour towards participants and feeling stigmatised and discriminated.
7. Additional comments.

Please see online supplemental materials for an overview of the online survey.

Patient and public involvement

Patients and public were involved from the outset and throughout the study, including the design, conducting, choice, development and piloting of the AAA survey, recruitment and reporting of the study.

Data analysis

Data from this survey produced quantitative and text data from validated questionnaires, and closed and open-ended questions.

For the statistical analysis, we fit generalised linear models to the data. Participant responses were used to calculate the WEMWBS and PHQ-9 scores for well-being and depression, respectively. We imputed missing values for participants who did not respond to all items needed to calculate WEMWBS and PHQ-9 scores. If a participant responded to at least 11 of the 14 WEMWBS items or at least 7 of the 9 PHQ-9 items, we used the mean value of the participant’s responses in place of missing values. WEMWBS, PHQ-9 and concerns regarding COVID-19 were treated as continuous outcomes. Logistic regression models were used to model (1) actions taken to mitigate the risk of contracting COVID-19, (2) the impact of COVID-19 on the management of health conditions and (3) the technology platforms used to receive healthcare. Responses regarding the impact of COVID-19 on lifestyle-related behaviours were modelled using multinomial and adjacent-category logit models assuming proportional odds. ORs and 95% CIs were reported for logistic, multinomial and adjacent-category logit models.

Each response was modelled as a function of the indicators for high risk of severe illness from COVID-19 (12 separate binary variables) which included: diabetes; body mass index (BMI) \(\geq 40\) kg/m\(^2\); chronic respiratory disease; chronic heart disease; chronic kidney disease (CKD); chronic liver disease; chronic neurological conditions; spleen problems; weakened immune system; aged over 70 years; pregnant and other, which included short-term or long-term health conditions. Other covariates in the
models were the participant’s gender (male or female), age (in years), BMI (numeric), Index of Multiple Deprivation (IMD; numeric: 1–10 as identified using the English Indices of Deprivation 2019), and whether the participant had multiple indicators for high risk (categorical: one, two, three or more conditions). Descriptive data were summarised with mean (SD) or median (IQR) for continuous data depending on data distribution, with categorical data summarised as counts (percentage, %). In each scenario, the reference group consisted of participants who do not belong to the specified high-risk group. All statistical analyses were performed using the tidyverse (V.1.3.0)\textsuperscript{9} and Vector Generalized Linear and Additive Model (VGAM) (V.1.1–2)\textsuperscript{10} packages in R (V.3.6.2).\textsuperscript{11} Statistical significance was defined at $p<0.05$. Text data were collected across 17 open-ended questions which were distributed throughout the survey sections. The language sample for each participant was processed to derive sentiment scores and personality scores. Valence Aware Dictionary and sEntiment Reasoner (VADER) Sentiment Analysis tool\textsuperscript{12} was used to obtain sentiment scores (positive, neutral, negative and compound sentiment). Personality scores were obtained using proprietary software by Scaled Insights. The software takes as input a language sample and produces 114 personality features. Following this, the 118 features (114 personality, 4 sentiment) were used as input into the multiple machine learning models, which were used in two settings: unsupervised (clustering) and supervised (classification or regression). We also investigated to what extent features obtained from a language sample are predictive of concerns, mitigating actions, impact on lifestyle behaviours, and well-being and depression scores in the context of COVID-19. For further details and an overview of the prediction models, see the online supplemental materials and supplemental tables S1–S4 for the overview of the prediction models, see the online supplemental material 1 for statistical analysis of COVID-19 concerns, risk mitigating behaviour and interactions with others).

**Impact of COVID-19 on lifestyle-related behaviours**
Online supplemental figures S1–S6 display the impact of COVID-19 on lifestyle-related behaviours for each high-risk indicator of severe illness from COVID-19. Generally, across all high-risk indicators a high proportion of participants indicated little to moderate change in diet, no change in alcohol consumption, less or much less physical activity, no change in the type of physical activity and a great deal of change in shopping habits. Change in quality and amount of sleep was variable across risk groups.

Further analysis of lifestyle-related behaviours compared with prior to COVID-19 lockdown suggested that women and participants with CKD were more likely to report greater change in their shopping habits compared with those without CKD (OR 1.18, 95% CI 1.02 to 1.38) and (OR 1.62, 95% CI 1.01 to 2.60), respectively; see online supplemental table S5. Participants were less likely to report greater changes in their diet for each additional year of age (OR 0.99, 95% CI 0.98 to 1.00), whereas participants with higher BMI and women reported greater change in their diet (OR 1.02 per additional kg/m$^2$, 95% CI 1.00 to 1.03 and OR 1.19, 95% CI 1.02 to 1.39) respectively. Furthermore, participants with either chronic respiratory disease, CKD, weakened immune systems or a higher BMI were less likely to report greater change in the amount of physical activity they engaged in compared with those who did not belong to any of these high-risk groups (OR 0.70, 95% CI (0.50 to 0.97); OR 0.65, 95% CI (0.44 to 0.96); OR 0.54, 95% CI (0.37 to 0.78) and OR 0.98 per additional kg/m$^2$, 95% CI (0.97 to 1.00), respectively). In addition, individuals with chronic neurological conditions were less likely to report a change in the type of physical activity they engaged in (OR 0.23, 95% CI (0.06 to 1.00)).

**Impact of COVID-19 on mental health, well-being**
Four hundred and forty-five (49.8%) participants indicated that their self-reported mental health was about the same compared with prior to COVID-19 lockdown (table 2). Women were more likely to report worsening of their mental health (OR 2.09, 95% CI 1.02 to 4.29)
whereas participants >70 years old were less likely to report worsening of their mental health (OR 0.16, 95% CI 0.03 to 0.86). Specifically, for each additional year of age, participants were more likely to report that their mental health had been impacted less negatively during COVID-19 lockdown (OR 1.04, 95% CI 1.01 to 1.08).

For all participants, mean well-being (WEMWBS) was 44.9±11.3—lower than the population well-being norm—and participants on average reported mild depression (PHQ-9) of 7.53±6.11. For median well-being and depression scores based on high-risk group, see online supplemental table S6.

Well-being
Participants who were older reported statistically higher well-being (WEMWBS). For each additional year, well-being increased by 0.25 (p<0.001). By contrast, women reported well-being that was 1.75 lower than those of men (p=0.048).

Depression
Pregnant women and older participants reported lower depression (PHQ-9), with pregnant women reporting scores 4.41 points lower than women who were not pregnant (p=0.048).

### Table 1
Demographics characteristics of participants in the AAA survey

| Participant Characteristics† | Yes | No |
|------------------------------|-----|----|
| Age‡ mean (SD: years)        | 54.6±14.9 | 54.8±14.5 |
| BMI‡ mean (SD: kg/m²; n=1003) | 28.8±8.1 | 28.3±8.2 |
| Index of Multiple Deprivation‡ mean (SD: n=759) | 5.33±2.7 | 5.22±2.6 |

| Gender n (%) | Male | Female |
|--------------|------|--------|
| Male         | 402 (39.2%) | 624 (60.8%) |
| Female       | 624 (60.8%) | 402 (39.2%) |

| Ethnicity n (%) | White-British, Irish, other | Black/black British-Caribbean, African, other | Chinese/Chinese British | Middle Eastern/Middle Eastern British-Arab, Turkish, other | Mixed race-other | Mixed race-white and black/black British | Other ethnic groups |
|-----------------|-----------------------------|---------------------------------------------|------------------------|-------------------------------------------------|----------------|-----------------------------------------|-------------------|
| White-British, Irish, other | 979 (95.4%) | 20 (1.9%) | 2 (0.2%) | 5 (0.5%) | 3 (0.3%) | 7 (0.7%) |
| Black/black British-Caribbean, African, other | 8 (0.8%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) |
| Chinese/Chinese British | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) |
| Middle Eastern/Middle Eastern British-Arab, Turkish, other | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) | 2 (0.2%) |
| Mixed race-other | 5 (0.5%) | 5 (0.5%) | 5 (0.5%) | 5 (0.5%) | 5 (0.5%) | 5 (0.5%) |
| Mixed race-white and black/black British | 3 (0.3%) | 3 (0.3%) | 3 (0.3%) | 3 (0.3%) | 3 (0.3%) | 3 (0.3%) |
| Other ethnic groups | 7 (0.7%) | 7 (0.7%) | 7 (0.7%) | 7 (0.7%) | 7 (0.7%) | 7 (0.7%) |

| Health or social care worker (n=1025) n (%) | Yes | No |
|---------------------------------------------|-----|----|
| Yes                                         | 150 (14.6%) | 875 (85.3%) |
| No                                          | 875 (85.3%) | 150 (14.6%) |

| Job requires contact with COVID-19 patients (n=144) n (%) | Yes | No |
|----------------------------------------------------------|-----|----|
| Yes                                                      | 39 (3.8%) | 105 (10.2%) |
| No                                                       | 105 (10.2%) | 39 (3.8%) |

| Diabetes n (%) | Yes | No |
|----------------|-----|----|
| Yes            | 538 (52.4%) | 488 (47.6%) |
| No             | 488 (47.6%) | 538 (52.4%) |

| BMI≥40 kg/m² n (%) | Yes | No |
|-------------------|-----|----|
| Yes                | 142 (13.8%) | 884 (86.2%) |
| No                 | 884 (86.2%) | 142 (13.8%) |

| Chronic respiratory disease n (%) | Yes | No |
|-----------------------------------|-----|----|
| Yes                               | 179 (17.4%) | 847 (82.6%) |
| No                                | 847 (82.6%) | 179 (17.4%) |

| Chronic heart disease n (%) | Yes | No |
|-----------------------------|-----|----|
| Yes                         | 132 (12.9%) | 894 (87.1%) |
| No                          | 894 (87.1%) | 132 (12.9%) |

| Chronic kidney disease n (%) | Yes | No |
|------------------------------|-----|----|
| Yes                          | 147 (14.3%) | 879 (85.7%) |
| No                           | 879 (85.7%) | 147 (14.3%) |

| Chronic liver disease n (%) | Yes | No |
|-----------------------------|-----|----|
| Yes                         | 49 (4.8%) | 977 (95.2%) |
| No                          | 977 (95.2%) | 49 (4.8%) |

| Chronic neurological conditions n (%) | Yes | No |
|--------------------------------------|-----|----|
| Yes                                  | 35 (3.4%) | 991 (96.6%) |
| No                                   | 991 (96.6%) | 35 (3.4%) |

| Spleen problems n (%) | Yes | No |
|-----------------------|-----|----|
| Yes                   | 16 (1.6%) | 1010 (98.4%) |
| No                    | 1010 (98.4%) | 16 (1.6%) |

| Weakened immune system n (%) | Yes | No |
|------------------------------|-----|----|
| Yes                          | 159 (15.5%) | 867 (84.5%) |
| No                           | 867 (84.5%) | 159 (15.5%) |

| Aged >70 years n (%) | Yes | No |
|---------------------|-----|----|
| Yes                 | 178 (17.3%) | 848 (82.7%) |
| No                  | 848 (82.7%) | 178 (17.3%) |

| Pregnant n (%) | Yes | No |
|---------------|-----|----|
| Yes           | 21 (2.0%) | 1005 (98.0%) |
| No            | 1005 (98.0%) | 21 (2.0%) |

| Other risk factors* n (%) | Yes | No |
|--------------------------|-----|----|
| Yes                      | 303 (29.5%) | 723 (70.5%) |
| No                       | 723 (70.5%) | 303 (29.5%) |

| No of high-risk groups n (%) | 1 | 2 | 3+ |
|------------------------------|---|---|----|
| Yes                          | 471 (45.9%) | 336 (32.7%) | 219 (21.3%) |
| No                           | 532 (50.1%) | 498 (47.2%) | 200 (19.2%) |

*Short-term or long-term health conditions, for example, mentalhealth.
†n=1026 except where otherwise specified.
‡Mean and SD.
AAA, attitudes and actions; BMI, body mass index.

### Table 2
Summary of WEMWBS and PHQ-9 scores and changes in self-reported mental health compared with pre-COVID-19

| Participant response | WEMWBS* (n=922) | PHQ-9* (n=927) |
|----------------------|------------------|----------------|
|                      | 44.9±11.3        | 7.53±6.11      |

| Mental health changes since COVID-19 (n=893) n (%) | Worse | About the same | Better |
|--------------------------------------------------|-------|----------------|--------|
| Yes                                              | 397 (44.5%) | 445 (49.8%) | 51 (5.7%) |
| No                                               | 445 (49.8%) | 51 (5.7%) | 397 (44.5%) |

*Mean and SD.
PHQ-9, Patient Health Questionnaire; WEMWBS, Warwick-Edinburgh Mental Well-being Scale.
pregnant (p=0.013), whereas for each additional year of age there was a reduction in depression by 0.14 points (p<0.001). In addition, participants’ weight impacted depression, with each unit increase in BMI, there was an increase of depression by 0.09; gender impacted depression with women reporting an average depression score that was 1.41 points higher than men; and participants with three or more indicators of high-risk reported greater depression with a mean increase of 4.78 compared with those with only one high-risk indicator (p<0.05 for all factors).

**Impact on management of health conditions and use of technology**

The impact of COVID-19 on the delivery of care for those with high-risk indicators is summarised in table 3. Six hundred and eighty-two (66.5%) participants indicated changes to their regular healthcare appointments, while 199 (19.4%) participants indicated that there were no changes to regular healthcare support during the COVID-19 lockdown.

Participants with chronic liver disease were more likely to report change to management of health conditions compared with prior to the COVID-19 lockdown (OR 3.15, 95% CI 1.29 to 8.01); see online supplemental table S7. Participants with either diabetes, weakened immune systems or liver disease were more likely to report change to appointments (OR 2.40, 95% CI 1.11 to 5.75) OR 2.90, 95% CI 1.18 to 7.93) and OR 3.48, 95% CI 1.16 to 12.16, respectively); whereas participants with spleen problems had a greater likelihood of reporting changes to their medications (OR 7.10, 95% CI 1.45 to 53.03). For each additional year of age, participants were more likely to report changes to elective surgery and their clinician (OR 1.03, 95% CI 1.01 to 1.06 and OR 1.03, 95% CI 1.01 to 1.05, respectively). However, participants who were >70 years old were less likely to report other changes to regular healthcare support beyond those specified in the survey (OR 0.24, 95% CI 0.05 to 0.88).

Four hundred and sixty-seven (45.5%) participants indicated that their care changed to using telephone support, while 321 (31.3%) reported that they did not use any of the platforms specified in the survey (table 3). Participants >70 years were less likely to use the telephone to receive care (OR 0.46, 95% CI 0.21 to 0.99). Participants living with liver disease were more likely to use social media (OR 5.91, 95% CI 1.62 to 20.84). In addition, participants with liver disease were more likely to report using virtual consultation platforms; as were participants with neurological conditions (OR 4.39, 95% CI 1.41 to 13.20) and OR 3.56, 95% CI 1.06 to 10.98, respectively). By contrast, women were less likely to use virtual consultation platforms compared with men (OR 0.56, 95% CI 0.32 to 0.98). For each additional year in age, participants were less likely to use emails (OR 0.98, 95% CI 0.96 to 1.00). When asked whether participants were satisfied with the support platforms and with the information received during the COVID-19 lockdown, the majority reported either being somewhat or extremely satisfied (40.3%, 39.6%, respectively; table 3).

Four hundred and sixty-six (45.4%) participants indicated that they would welcome continued use of the platforms used during COVID-19 lockdown. When comparing gender, women were less satisfied with the platform they used (OR 0.84, 95% CI 0.72 to 0.99); however, the level of satisfaction with using the information provided through the platform was similar across all groups. Age appeared to impact whether participants wished to continue to use the healthcare platform after COVID-19 lockdown (OR 1.03 for each additional year of age, 95% CI 1.01 to 1.06). While those with greater social deprivation appeared to

| Table 3 Summary of participant changes to clinical management during COVID-19 lockdown |
|-----------------------------------|-------------|-----------------|-----------------|-----------------|-----------------|
| Changes to regular healthcare support? n (%) | 682 (66.5%) | 292 (28.5%) | 122 (11.9%) | 183 (17.8%) | 196 (19.1%) |
| Medication | 83 (8.1%) | 83 (8.1%) |
| Elective surgery | 199 (19.4%) | 199 (19.4%) |
| Communication platform | No change | No change |
| Clinician | No platforms | No platforms |
| Other | No platforms | No platforms |
| Face to face care | No platforms | No platforms |
| How satisfied are you with the platforms? (n=860) n (%) | Extremely satisfied | Somewhat satisfied | Somewhat dissatisfied | Extremely dissatisfied | 
| Extremely dissatisfied | 51 (6.0%) | 234 (22.8%) | 180 (17.5%) | 41 (4.0%) | 114 (11.1%) |
| Somewhat dissatisfied | 92 (9.0%) | 255 (24.3%) | 306 (29.5%) | 114 (11.1%) | 306 (29.5%) |
| Neither satisfied nor dissatisfied | 306 (29.5%) | 255 (24.3%) | 306 (29.5%) | 306 (29.5%) | 306 (29.5%) |
| Somewhat satisfied | Extremely satisfied | 151 (14.7%) |
| Extremely satisfied | Use platforms after COVID-19? (n=875) n (%) | No | No platforms | Other | No, but would welcome other platforms |
| No | Not sure, I need more time to use them | 466 (45.4%) |
| No | Yes | 174 (17.0%) |
| No | No platforms | 83 (7.9%) |
| No platforms | Other | 83 (8.1%) |
| Other | Other | 83 (8.1%) |
| Other | Other | 83 (8.1%) |
| Other | Other | 83 (8.1%) |
be unsure about continuing to use the platform (OR 1.10 for each increased in IMD, 95% CI 1.02 to 1.19).

**Concerns about COVID-19**

A large proportion of participants in each high-risk group reported that they were ‘very concerned’ to statements about infection, spread and potential impact of COVID-19; see online supplemental figures S7–S12.

Participants with either chronic respiratory disease, chronic heart disease, CKD, other acute/chronic diseases, diabetes or weakened immune systems were more concerned about becoming infected compared with those who did not belong to any of these high-risk groups (p<0.05). The coefficients for these covariates suggest that participants in either of these high-risk groups selected the next highest response compared with individuals who believed they were not at high risk. Additionally, concerns about being infected were significantly higher for women than in men (difference 0.59; p=0.003), and for older participants (difference 0.02; p=0.032), although the differences were relatively small. Participants with either chronic respiratory disease, chronic heart disease, CKD, BMI ≥40 or weakened immune systems were more concerned about experiencing severe illness or death (next highest response) compared with those who did not belong to these high-risk groups (p<0.05); whereas pregnant women were less concerned (2.10 points lower) than women who were not pregnant (p=0.012).

Participants with chronic respiratory disease were significantly more concerned (next highest response) about access to healthcare support (p=0.020). There were no statistically significant factors for the models with the following concerns: spreading COVID-19 to others; receiving appropriate care/support; and potentially receiving disparate healthcare support due to higher-risk status. This suggests that high concern was similar across all high-risk groups.

**Mitigating COVID-19**

More than 50% of participants in each high-risk group practised social distancing with the exception of those with weakened immune systems (n=71; 44.7%); see online supplemental table S8. Twenty-one (60%) participants with chronic neurological diseases and 102 (57.3%) aged 70 years or older self-isolated. Twenty-eight (57.1%) participants with chronic liver disease, 18 with chronic neurological disease, and 96 (53.9%) aged 70 years or older used online shopping or food delivery. Eighty-five (53.5%) participants with weakened immune systems and 11 (68.8%) with spleen problems used shielding. Less than 50% of participants in each high-risk group wore protective apparel or took all of the actions specified in the survey.

Participants living with diabetes were also more likely to wear protective apparel (OR 2.17, 95% CI 1.13 to 4.14); while participants with people >70 years and chronic liver disease were more likely to shop online (OR 2.66, 95% CI 1.24 to 5.88 and OR 3.34, 95% CI 1.42 to 8.14, respectively). Participants with either CKD, weakened immune systems or spleen problems were more likely to practise shielding (OR 2.76, 95% CI 1.21 to 6.31; OR 3.33, 95% CI 1.55 to 7.22 and OR 5.33, 95% CI 1.15 to 28.78, respectively). Finally, participants with weakened immune systems were more likely to take all mitigating risk actions identified (OR 2.61, 95% CI 1.01 to 6.41). There were no statistically significant differences between high-risk groups with regard to self-isolation.

**Interactions with others and stigma**

Three hundred and seventy-seven (41.0%) participants indicated that people behaved differently towards them compared with prior to COVID-19 lockdown. When asked if during the COVID-19 lockdown they felt more stigmatised or discriminated against 119 (13.0%) reported they had compared with prior to COVID-19 lockdown. Of these participants, 65 (54.6%) were living with diabetes, 25 (21.0%) had a BMI of ≥240 kg/m², 21 (17.6%) had chronic respiratory disease, 24 (20.2%) had a weakened immune system and 44 (37%) had other chronic short-term or long-term risk factors. In all other high-risk groups fewer than 20 participants said that they felt stigmatised or discriminated against.

Participants with chronic neurological diseases were less likely to report that people behaved differently towards them (OR 0.23, 95% CI 0.06 to 1.00). There were no discernible differences between the high-risk groups with regard to feelings of stigma and discrimination compared with prior to COVID-19 lockdown.

**Exploration and prediction using text-derived features**

**Clustering**

The personality and sentiment features were used as input to a clustering algorithm (k-means) in order to separate survey participants into groups. As the k-means algorithm requires to specify the number of clusters, we first experimented with different values of k (between 2 and 10). We used two heuristics (sum of squared distance and an elbow plot, and degree of separation between clusters and a silhouette plot) to evaluate which k value resulted in most coherent and disparate clusters. According to both heuristics, two clusters resulted in the best differentiation: the first cluster with 335 participants and second with 301 participants (see figure 1 for a visualisation of the clusters). Table 4 lists the 10 most differentiating features and the cluster centroid values. The first cluster had a negative compound sentiment score and higher values for neuroticism, insecurity, ‘type A’ personality (ie, more competitive and ambitious), aggression, stress and coldness, while the second cluster had a positive compound sentiment score and higher values for dutifulness, cooperation and social skills.
DISCUSSION

This study provides the essential evidence to start addressing the dearth of detailed information regarding the impact of COVID-19 on the 2.2 million people identified at higher risk of severe illness from COVID-19 and advised to shield during lockdown.

During the COVID-19 lockdown, the management of health conditions among people identified as at high risk of severe illness changed. Nearly half of the sample reported using telephone care, with people aged 70 years or over less likely to use telephone care. People living with diabetes and liver disease reported the greatest use of social media, while people living with chronic liver disease and neurological conditions were most likely to use virtual consultations. The majority of participants reported that they were satisfied with the new platforms and the information provided to manage their health conditions, and importantly would welcome continued use. Notably, people living in higher deprivation reported greater uncertainty about continued use which may identify concerns regarding internet poverty and inability to access digital care within this community. It is imperative that new technologies for supporting people living with health conditions are accessible for all, and does not disproportionately impact subgroups of the population and potentially widen health inequalities. Indeed, the higher prevalence of chronic health conditions among people living in more deprived communities, and the disproportionate impact of COVID-19 infection on people living in poorer communities, highlights the need to address these concerns or uncertainty, given the likelihood of continued short-term and long-term use of new technologies to support patient care.

Emerging evidence has demonstrated that the COVID-19 lockdown and restrictions have impacted lifestyle behaviours such as decrease in physical activity and sleep deprivation, although this has predominantly focused on the general population. Current study findings provide novel evidence about the impact on people identified as at high risk of severe illness from COVID-19 infection, and thus, people who have needed to follow greater restrictions. Reductions in physical activity were also observed for people with chronic respiratory disease, CKD and weakened immune system, which would be consistent with those who may have avoided venturing outside due to risk of COVID-19 infection. Across all groups, people reported that their sleep quality and amount was impacted.

As the pandemic has progressed, a greater emphasis has been placed on the impact that lockdown, restrictions on daily life including meeting with significant others, the loss of loved ones, the loss of work and others have had on mental health. This study demonstrates that for the majority of the sample, the pandemic has led to worse mental health, with only 6% reporting an improvement. This was greater than the 35% of vulnerable people reporting worse mental health from the Office of National Statistics. This may have been due to...
Table 5 Comparison between clusters of actions, concerns, lifestyle behaviours, depression and well-being scores, impact on health management, and use of platforms for health management. Numeric variables were compared using t-test, binary variables were compared using proportions z-test.

|                                | Negative Cluster | Positive Cluster | Test result | P value |
|--------------------------------|------------------|------------------|-------------|---------|
| **Actions**                    |                  |                  |             |         |
| Social distancing              | 303              | 188              | 0.83        | 0.41    |
| Self-isolation                 | 202              | 104              | −1.72       | 0.09    |
| Wearing protective apparel     | 127              | 81               | 0.55        | 0.58    |
| Online shopping                | 187              | 117              | 0.53        | 0.60    |
| Shielding                      | 109              | 64               | −0.14       | 0.89    |
| All above                      | 51               | 26               | −0.71       | 0.48    |
| **Concerns**                   |                  |                  |             |         |
| Becoming infected              | 7.72             | 7.05             | −3.29       | <0.01   |
| Severe illness or death        | 7.88             | 7.25             | −2.82       | 0.01    |
| Spreading COVID-19 to others   | 7.12             | 6.76             | −1.44       | 0.15    |
| Access to healthcare           | 6.06             | 4.97             | −4.28       | <0.01   |
| Appropriate care if infected   | 6.88             | 5.76             | −4.22       | <0.01   |
| Worse care compared with low-risk individuals | 6.02 | 5.05 | −3.23 | <0.01 |
| **Lifestyle**                  |                  |                  |             |         |
| Shopping                       | 3.31             | 3.22             | −1.16       | 0.25    |
| Diet                           | 1.75             | 1.41             | −3.72       | <0.01   |
| Alcohol consumption            | 0.05             | 0.09             | 0.62        | 0.53    |
| Physical activity (amount)     | −0.78            | −0.28            | 5.25        | <0.01   |
| Physical activity (type)       | 0.75             | 0.78             | 0.8         | 0.43    |
| Sleep                          | 1.93             | 1.37             | −5.15       | <0.01   |
| Smoking (indicated yes)        | 0.05             | 0.01             | −2.81       | 0.01    |
| Smoking (impact)               | 0.15             | 0                | −0.16       | 0.87    |
| E-cigarettes (indicated yes)   | 0.04             | 0.03             | −1.14       | 0.25    |
| E-cigarettes (impact)          | 0.53             | 0.33             | −0.48       | 0.64    |
| Recreational drugs (indicated yes) | 0.02 | 0.02 | −0.07 | 0.94 |
| Recreational drugs (impact)    | 0.29             | 0                | −0.37       | 0.72    |
| **Depression**                 |                  |                  |             |         |
| PHQ-9 score                    | 9.16             | 5.49             | −7.63       | <0.01   |
| **Well-being**                 |                  |                  |             |         |
| WEMWBS score                   | 42.23            | 49.36            | 8.29        | <0.01   |
| **Change to healthcare support**|                  |                  |             |         |
| General management             | 398              | 237              | −1.29       | 0.2     |
| Appointments                   | 311              | 161              | −2.93       | <0.01   |
| Medication                     | 146              | 75               | −1.33       | 0.19    |
| Elective surgery               | 50               | 36               | 0.91        | 0.36    |
| Communications platform        | 84               | 44               | −0.8        | 0.43    |
| Clinician                      | 91               | 50               | −0.55       | 0.59    |
| Other                          | 50               | 21               | −1.45       | 0.15    |
| No change                      | 55               | 60               | 3.61        | <0.01   |
| **Platforms used to receive care** |                  |                  |             |         |
| Social media                   | 23               | 19               | 1.08        | 0.28    |
| Mobile phone app               | 34               | 34               | 2.27        | 0.02    |
| Email                          | 60               | 35               | −0.13       | 0.90    |
| Telephone                      | 219              | 111              | −2.05       | 0.04    |
| Virtual consultation           | 43               | 23               | −0.46       | 0.65    |
| Other                          | 18               | 18               | 1.61        | 0.11    |
| No new platforms               | 118              | 79               | 0.94        | 0.35    |
| Still face-to-face             | 18               | 9                | −0.45       | 0.65    |
| Satisfied with platforms       | 0.39             | 0.7              | 3.32        | <0.01   |
| Satisfied with information     | 0.33             | 0.64             | 3.46        | <0.01   |
| Continue using in the future   | 186              | 124              | 1.31        | 0.19    |

Test results and p values were rounded to two decimal places. PHQ-9, Patient Health Questionnaire; WEMWBS, Warwick-Edinburgh Mental Well-being Scale.
population differences but overall represents a consistent message that lockdown had a negative impact on people’s self-reported mental health. In alignment, mean well-being was lower than the national average, and depression was higher than that found in a general population sample from the COVID-19 Social Study. The statistical analysis demonstrates that young women who are at risk of severe illness from COVID-19 report that their mental health has been most negatively impacted, have lower well-being and higher depression. This is consistent with other data showing that depression was higher in young people, suggesting that the lockdown restrictions have more negatively impacted younger people and requires greater consideration. Moreover, people with a higher BMI or with multiple risk factors reported the highest depression, which may well be expected given the link between obesity and depression. Given that this study highlights the impact of the COVID-19 pandemic on the mental health of people identified as at high risk of severe illness, policy-makers, community groups and health charities should consider how and in what ways they can best support or refer people whose mental health may have been compromised—which for many may go above and beyond their usual activities. This may involve policymakers considering how and in what ways to support in particular health charities to provide this care given economic challenges facing many during the pandemic and the reduction in access to clinical services.

Artificial intelligence methods were applied to the data to consider how intrinsic factors, specifically personality and sentiment, derived from language samples could provide additional insights into people’s actions and attitudes relating to COVID-19. Based on those intrinsic factors, the participants clustered into two groups. Crucially, the two groups differed significantly in their responses. Compared with the positive cluster (with higher dutifulness and cooperation scores and positive sentiment), the negative cluster had higher neuroticism, insecurity score and negative sentiment and reported higher levels of concern, greater negative impact on lifestyle behaviours, higher depression and lower well-being, alongside lower satisfaction with platforms used to deliver their healthcare during COVID-19. Furthermore, when predicting actions or attitudes for individuals, word vectors (features derived from language samples) achieved fairly good to good prediction performance (between 0.7 and 0.8 Area Under Receiver Operating Characteristics (AUROC)). On the other hand, personality and sentiment features were better predictors of depression and well-being than word vectors. Overall, current study data suggests that analysing language samples using Artificial Intelligence could yield useful insights into people’s AAA relating to COVID-19 and effectively identify individuals at higher risk. Future work can explore the feasibility of using these methods as a preventative support measure, by using them within a digital environment to identify whether someone is likely to be more significantly impacted and offer them appropriate support.

This study is not without limitations. First, it provides a cross-sectional analysis, and as such informs about the COVID-19 lockdown period. Nevertheless, this study provides much needed insights about a subsection of the population who have been subject to greater restrictions and as the findings demonstrate, have been impacted in terms of access to healthcare, lifestyle behaviours and mental health. Second, due to the recruitment methods, the sample was not totally representative, has used a self-recruitment methods which may have led to a more motivated sample and would not have recruited people experiencing digital poverty. Finally, given the reported increased risk for people from black and minority ethnic (BAME) backgrounds, the low recruitment of people from BAME backgrounds means that comparison of the impact on people of different ethnic backgrounds was not possible.

Further research to assess the longer term impact of COVID-19 on people identified at high risk is needed. This research should provide insights into the longer term changes to healthcare access, provision and support, and where relevant, how technological platforms have facilitated continued care. This study demonstrated the adults identified as high risk of severe illness from COVID-19 reported lower well-being, that their mental health had worsened and varied levels of depression. Given the continued restrictions for many people within this population subgroup, and thus the associated impact on other areas of life including employment, future research should assess the longer term impact on mental health. Indeed, it might be argued that people with mental health concerns may also be at high risk from the impact of COVID-19 and as such, appropriate measures and support made available. Finally, research is also needed to understand the impact of delayed healthcare support such as elective surgery.

CONCLUSIONS

This study provides novel insights into the awareness, AAA of UK adults identified as at high risk of severe illness from COVID-19. In particular, this study demonstrates that the pandemic has impacted people’s access to healthcare support, lifestyle behaviours and mental health. Furthermore, the use of an innovative artificial intelligence tool has demonstrated the advanced insights that can be gleaned from patient language samples to predict behaviours and health outcomes in response to the COVID-19 pandemic. This has the potential to enable clinicians to identify people at greater risk and highlights the value of using artificial intelligence within healthcare, particularly during the COVID-19 pandemic.

As such, there are important implications for policy-makers, healthcare and clinical practice as well as healthcare technology companies. Working with adults identified as at high risk of severe illness from COVID-19, action is needed that aims to address issues relating to access to healthcare, attitudes towards use of technological
platforms and to support people’s mental health. The findings demonstrate that healthcare access and support has been significantly impacted, that their lifestyle-related behaviours have changed and that mental health has worsened. It is paramount to not only but take actions to reduce any potential unintended consequences of the restrictions placed on daily life, which may avoid exacerbating physical and mental health concerns.

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Contributors
SW conceived the study. SWF, AB and AAT contributed to the study design and methodology. SWF was responsible for the oversight of the study. SWF, AB and AAT contributed to the recruitment of participants. AP and A-CJ were responsible for data analysis. All authors contributed to data interpretation, and the writing of the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content and gave final approval.

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Not required.

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Supplemental material
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Supplementary materials

1. Awareness, Attitudes and Actions (AAA) survey
2. Supplementary data analysis
3. Statistics tables and figures
4. AI prediction models
### Awareness, Attitudes and Actions (AAA) survey

| Survey questions                                                                 | Response categories/instruction                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Section A: demographics**                                                      | Diabetes (Type 1 or 2)  
A body mass index (BMI) of 40 or above  
Chronic (long-term) respiratory diseases, such as asthma, chronic obstructive pulmonary disease (COPD), emphysema or bronchitis  
Chronic heart disease, such as heart failure  
Chronic kidney disease  
Chronic liver disease, such as hepatitis  
Chronic neurological conditions, such as Parkinson's disease, motor neurone disease, multiple sclerosis (MS), a learning disability or cerebral palsy  
Problems with your spleen – for example, sickle cell disease or if you have had your spleen removed  
A weakened immune system as the result of conditions such as HIV and AIDS, or medicines such as steroid tablets or chemotherapy  
None of these apply to me  
I have a different long term health condition not listed above (please specify in the text box provided) |                                                                                                                                                                                                                                    |
| Please state your age                                                            | Textbox                                                                                                                                                                                                                          |
| Gender                                                                           | Male  
Female  
Other (textbox)  
Prefer not to say                                                                                                                                                                                                            |
| What is your ethnicity?                                                          | White – British, Irish, other  
Asian/Asian British – Indian, Pakistani, Bangladeshi, other  
Chinese/Chinese British  
Black/Black British – Caribbean, African, other  
Middle Eastern/Middle Eastern British – Arab, Turkish, other  
Mixed race – White and Black/Black British  
Mixed race – other  
Other ethnic groups (please specify in the text box provided)  
Prefer not to say                                                                                                                                                  |
| What is your height in feet and inches, or centimetres?                          | Text box provided for each                                                                                                                                                                                                         |
| What is your weight in pounds or kilograms?                                      | Text box provided for each                                                                                                                                                                                                           |
| Do you work in health or social care? | Yes (please provide your job title in the text box) |
|--------------------------------------|--------------------------------------------------|
|                                      | No                                               |
| Does your job require you to be in direct contact with coronavirus (COVID-19) patients? | Yes |
|                                      | No                                               |
| Please provide the first half of your postcode (e.g. NG1) | Textbox provided |
| Please provide your email address | Textbox provided |

**Section B: awareness, attitudes and actions relating to COVID-19**

| Have you had coronavirus? | Yes – I have been diagnosed and am still ill |
|                          | Yes – I have and I have recovered |
|                          | Yes - I have been diagnosed, but had no symptoms |
|                          | No |
| Have you experienced coronavirus symptoms? | Yes - and I was diagnosed |
|                                          | Yes – but I have not been diagnosed |
|                                          | No |
|                                          | I don’t know what the symptoms |

**Which of the below are symptoms of coronavirus?**
(Select all that is relevant)

- Persistent cough
- Feeling confused
- Loss of appetite
- Loss of smell
- Loss of taste
- Tightness in chest
- Diarrhoea
- Fatigue
- Shortness of breath
- Fever
- Sore throat
- None of the above

| Have you taken any of the actions below in response to the coronavirus (COVID-19) outbreak? (select all that apply) | Social distancing |
|                                                                                                                  | Self-isolation |
|                                                                                                                  | Worn protective apparel (e.g. gloves, mask etc.) |
|                                                                                                                  | Used online shopping or food delivery service |
|                                                                                                                  | Shielding due as my health status means I am defined as 'extremely vulnerable' |
|                                                                                                                  | All of the above |
|                                                                                                                  | Other (Textbox) |

| Do you believe you are at higher risk of severe illness from coronavirus (COVID-19)? | Yes |
|                                                                                     | No |

| Why do you believe you are at a higher risk of severe illness from coronavirus (COVID-19)? (only for those who answered yes) | Textbox |
|                                                                                                                                  |
| Why do you believe you are not at a higher risk of severe illness from coronavirus (COVID-19)? (only for those who answered no) | Textbox |
|                                                                                                                                  |
| Question                                                                 | Response |
|-------------------------------------------------------------------------|----------|
| Describe how being identified as being at a higher risk of severe illness from coronavirus (COVID-19) by the UK Government, has made you feel? | Textbox  |
| What sources have informed you that you are at a higher risk from coronavirus (COVID-19)? (select all that apply) | Traditional media (TV, Newspapers, Radio) Social media (Twitter, Facebook, Instagram, Snapchat) National or Local Government Employer Healthcare organisations Community groups Charity Friends and Family Schools and education centres Other (please specify in the text box provided) |
| Do you feel like you have enough information specific to your higher risk of severe illness from coronavirus (COVID-19)? | Yes No |
| Why do you believe you have received enough information specific to your higher risk of severe illness from coronavirus (COVID-19), and what more do you want to know? (only for those who answered yes) | Textbox  |
| Why do you believe you have not received enough information specific to your higher risk of severe illness from coronavirus (COVID-19), and what else do you want to know? (only for those who answered no) | Textbox  |
| Have you used other forms of information (i.e. nonprofessional/social media “experts”/other people/patients) since the COVID-19 outbreak? | Yes No |
| Please specify what information you have used relating to your higher risk status since the coronavirus (COVID19) outbreak | Textbox  |
| How concerned are you about each of the statements below | Likert scale from 0 (Not concerned at all) to 10 (Very concerned) |
| - Becoming infected with coronavirus (COVID-19)                  |          |
| - Severe illness and possibly death from coronavirus (COVID-19)    |          |
| - Spreading coronavirus (COVID-19) to others including family and friends |          |
| - Access to healthcare support (e.g. advice, medication)           |          |
| - If you become infected, that you would receive appropriate care/support |          |
| - That your higher risk of severe illness from coronavirus (COVID-19) means you may not |          |
### Section C: impact of COVID-19 on management of health conditions and use of technology

| Question                                                                 | Options/Notes                                                                 |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Has your management of your health condition changed compared to before the coronavirus (COVID-19) outbreak? | Yes, No, Not applicable (70 years or over or pregnant without a health condition) |
| How and why has it changed?                                              | Textbox                                                                      |
| How do you feel about changing your management of your health condition due to the coronavirus (COVID-19) outbreak? | Textbox                                                                      |
| Has COVID-19 changed your regular healthcare support? (this could type or frequency of support e.g. appointments, service, medications, communication consultant) | Appointments (please specify in the text box)  
Medical (please specify in the text box)  
Elective surgery (please specify in the text box)  
Communication platform (please specify in the text box)  
Clinician caring for me (please specify in the text box)  
Other (please specify in the text box)  
There has been no change |
| Have you received care through any of the following platforms?           | Social media (please specify in the text box)  
Mobile phone app (please specify in the text box)  
Email  
Telephone Virtual consultation e.g. Zoom, Microsoft Teams (please specify in the text box)  
Other (please specify in the text box)  
No platforms have been used  
I am still receiving face to face care |
| How satisfied are you with using the platforms that you are receiving care through? | Extremely dissatisfied  
Somewhat dissatisfied  
Neither satisfied nor dissatisfied  
Somewhat satisfied  
Extremely satisfied |
| How satisfied are you with using the information/resources provided through the platforms that you are receiving care through? | Extremely dissatisfied  
Somewhat dissatisfied  
Neither satisfied nor dissatisfied  
Somewhat satisfied  
Extremely satisfied |
| Would you welcome the continued use of these platforms in the future, after the coronavirus (COVID-19) outbreak? | Yes  
No, but would welcome other platforms (please specify in the text box)  
No  
Not sure, I need more time to use them |
You indicated that you have more than one of the high risk indicator for severe illness from coronavirus (COVID19). Please describe how this makes you feel, and why?

### Section D: Mental Health and Wellbeing

Since the coronavirus (COVID-19) outbreak, my mental health is

|   | Yes | No |
|---|-----|----|

Warwick-Edinburgh Mental Well-being Scale (WEMWBS)

During the past two weeks...

- I’ve been feeling optimistic about the future
- I’ve been feeling useful
- I’ve been feeling relaxed
- I’ve been feeling interested in other people
- I’ve had energy to spare
- I’ve been dealing with problems well
- I’ve been thinking clearly
- I’ve been feeling good about myself
- I’ve been feeling close to other people
- I’ve been feeling confident
- I’ve been able to make up my own mind about things
- I’ve been feeling loved
- I’ve been interested in new things
- I’ve been feeling cheerful

|   | Not at all | Rarely | Some of the time | Often | All of the time |
|---|------------|--------|------------------|-------|---------------|

Patient Health Questionnaire (PHQ-9)

Over the last two weeks, how often have you been bothered by any of the following problems

- Little interest or pleasure in doing things?
- Feeling down, depressed, or hopeless?
- Trouble falling or staying asleep, or sleeping too much?
- Feeling tired or having little energy?
- Poor appetite or overeating?
- Feeling bad about yourself - or that you are a failure or have let yourself or your family down?
- Trouble concentrating on things, such as reading the newspaper or watching television?
- Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual?
- Thoughts that you would be better off dead, or of hurting yourself in some way?

|   | Not at all | Several days | More than half the days | Nearly every day |
|---|------------|--------------|------------------------|------------------|

### Section D: lifestyle related behaviours
| Question                                                                 | Option                                |
|-------------------------------------------------------------------------|---------------------------------------|
| Has your shopping changed since the coronavirus (COVID-19) outbreak?     | A great deal                           |
|                                                                        | A lot                                  |
|                                                                        | A moderate amount                      |
|                                                                        | A little                               |
|                                                                        | Not at all                             |
| Describe how your shopping has changed since the coronavirus (COVID-19) outbreak | Textbox                               |
| Has your diet changed since the coronavirus (COVID-19) outbreak?         | A great deal                           |
|                                                                        | A lot                                  |
|                                                                        | A moderate amount                      |
|                                                                        | A little                               |
|                                                                        | Not at all                             |
| Describe how your diet has changed since the coronavirus (COVID-19) outbreak | Textbox                               |
| Has your alcohol consumption changed since the coronavirus outbreak?    | I have consumed much less alcohol than usual |
|                                                                        | I have consumed less alcohol than usual |
|                                                                        | It hasn't changed                      |
|                                                                        | I have consumed more alcohol than usual |
|                                                                        | I have consumed much more alcohol than usual |
| Why has your alcohol consumption changed since the coronavirus (COVID-19) outbreak? | Textbox                               |
| Has the amount of physical activity you usually engage in changed since the coronavirus outbreak? | I am much less active                  |
|                                                                        | I am less active                       |
|                                                                        | It hasn't changed                      |
|                                                                        | I am more active                       |
|                                                                        | I am much more active                  |
| Has the type of physical activity you usually engage in changed since the coronavirus outbreak? | Yes                                    |
|                                                                                                                                               |
|                                                                                                                                               |
| Describe how and why your physical activity has changed since the coronavirus outbreak            | No                                     |
|                                                                                                                                               |
|                                                                                                                                               |
| Has the amount or quality of your sleep changed since the coronavirus outbreak?                 | A great deal                           |
|                                                                                                                                               |
|                                                                                                                                               |
|                                                                                                                                               |
|                                                                                                                                               |
| Describe how and why the amount or quality of your sleep has changed since the coronavirus outbreak | Textbox                               |
|                                                                                                                                               |
|                                                                                                                                               |
| Do you smoke tobacco?                                                   | Yes                                    |
|                                                                                                                                               |
|                                                                                                                                               |
| Has the amount of tobacco you smoke changed compared to before the coronavirus (COVID-19) outbreak? | Much more                              |
|                                                                                                                                               |
|                                                                                                                                               |
|                                                                                                                                               |
| Do you use e-cigarettes?                                                | Yes                                    |
|                                                                                                                                               |
|                                                                                                                                               |
## Section E: Interaction with others

For the following questions, please respond with your health condition or higher risk status (70 years old or over or pregnant regardless of medical conditions) in mind. Since the coronavirus (COVID-19) outbreak...

| Question                                                                 | Options                                                                 |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Has the amount of e-cigarettes you use changed compared to before the coronavirus (COVID19) outbreak? | Much more
|                                                                          | Somewhat more                                                          |
|                                                                          | About the same                                                          |
|                                                                          | Somewhat less                                                           |
|                                                                          | Much less                                                              |

| Other than alcohol or tobacco, do you use any recreational drugs?       | Yes
|                                                                          | No

| Has the amount of recreational drugs you use changed compared to before the coronavirus (COVID19) outbreak? | Much more
|                                                                          | Somewhat more                                                          |
|                                                                          | About the same                                                          |
|                                                                          | Somewhat less                                                           |
|                                                                          | Much less                                                              |

## Final section

| Is there anything that you haven’t had chance to say about the coronavirus outbreak that you would like to share? | Textbox |

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Supplementary Data analysis

Text Data

Text data was collected across 17 open-ended questions which were distributed throughout the survey sections. All responses to open-ended questions were concatenated, yielding a language sample for each survey participant, which was then tokenised using spaCy’s large English web model\[1\]. The length of the concatenated responses (i.e. the number of tokens, including words, digits, and punctuation) varied from 1 to 2125 tokens (mean=184, median=135). The language sample for each participant was further processed to derive sentiment scores and personality scores. VADER Sentiment Analysis tool (Hutto & Gilbert, 2014) was used to obtain sentiment scores (positive, neutral, negative, and compound sentiment). Personality scores were obtained using proprietary software by Scaled Insights. The software takes as input a language sample and produces 114 personality features. Following this, the 118 features (114 personality, 4 sentiment) were used as input into the multiple machine learning models described below. As the reliability of the personality modelling software depends on the number of words provided in the language sample, the following analysis was restricted to participants (N=636) whose combined text response consisted of at least 100 tokens. The machine learning was used in two settings: unsupervised (clustering) and supervised (classification or regression).

In addition to the clustering, we investigated to what extent features obtained from a language sample could be used for predicting concerns, mitigating actions, impact on lifestyle behaviours, and wellbeing and depression scores in the context of COVID-19. A model which predicts these attitudes and behaviours and requires only a language sample could potentially be used within a digital environment to better identify people who might be more likely to be negatively impacted and offer them preventative support.

For each attitude or behaviour we trained a separate binary or multi-class classifier. We first explored a range of different classifiers (logistic regression, support vector machine, stochastic gradient descent classifier, and Random Forest). Across all classifiers we found that Random Forest achieved the best results, and we tuned the parameters for each classifier separately. The tuned parameters were then used to train the final classifiers using 10-fold cross-validation. As there were only sufficient language samples for 636 participants, we also trained classifiers using GloVe word vectors obtained from the same language model as the tokens. By using word vectors, we were able to train prediction models using all participants’ data.

All classification problems were evaluated using the Area Under the Receiver Operating Characteristics (AUROC) metric, while regression problems were evaluated using Mean Absolute Error (MAE) and explained variance.

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1 https://spacy.io/models/en#en_core_web_lg
Prediction models

Concerns about COVID-19

The responses relating to concerns were all expressed on a [1,10] scale. To form classes, the values were split into ‘slight’ (1-3), ‘some’ (4-7) and ‘great’ (8-10). Word vectors achieved the best performance with AUROC ranging from 0.71 to 0.78; see Supplementary Table 3.

Mitigating COVID-19

The mitigating actions each formed a binary class (i.e. someone either used particular mitigation action or not). Best performance was achieved by word vectors with AUROC ranging between 0.67 and 0.82. In the case of a more unbalanced class (predicting someone taking all possible mitigating actions), the best AUROC score (0.68) was achieved by personality and sentiment features; see Supplementary Table 2.

Impact of COVID-19 on Health and Lifestyle Related Behaviours

The responses on the impact of COVID-19 on lifestyle behaviours, used scales which were converted to classes as follows. Scale [-2,2] (used for alcohol consumption, physical activity, smoking, e-cigarettes, and recreational drug use) was converted to ‘Decrease’ [-2,-1], ‘No Change’ [0], ‘Increase’ [1,2]. Scale [0,4] (used for shopping, diet and sleep) was converted to ‘No or little impact’ [0,1], ‘Some impact’ [2], ‘Great impact’ [3,4]. For the lifestyle behaviours which were not well represented in the survey cohort (smoking, e-cigarettes, and recreational drug use) the results are very low (AUROC slightly better than random at 0.53 for recreational drug use). The best classifiers for other lifestyle behaviours had AUROC scores between 0.72 and 0.81; see Supplementary Table 4.

Impact of COVID-19 on Wellbeing

The scores for WEMWBS and PHQ-9 for both measures were used directly as target variables in the regression models. Unlike the prediction models reported previously, for both wellbeing and depression scores the best performing models used personality and sentiment scores. The model for depression achieved MAE = 4.25 and explained variance of 0.15, while the wellbeing model achieved MAE=7.97 and explained variance of 0.17; see Supplementary Table 5.

Supplementary Table 1. Prediction results for mitigating actions using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                | Social distancing | Self-isolation | PPE | Online shopping | Shielding | All above |
|----------------|-------------------|----------------|-----|-----------------|-----------|-----------|
| # positive class | 491               | 306            | 208 | 304             | 173       | 77        |
| # negative class | 145               | 330            | 428 | 332             | 463       | 559       |
| Personality and sentiment features | 0.66 | 0.55 | 0.51 | 0.49 | 0.62 | 0.68 |
| Word vectors | **0.82** | **0.7** | **0.67** | **0.68** | **0.73** | 0.54 |
| All features | 0.71 | 0.58 | 0.51 | 0.52 | 0.69 | 0.67 |
### Supplementary Table 2. Prediction results for concerns using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                          | Becoming infected | Severe illness or death | Spreading to others | Access to healthcare | Enough support | Less care compared to low risk |
|--------------------------|-------------------|-------------------------|---------------------|----------------------|----------------|------------------------------|
| # Slight concern         | 60                | 71                      | 114                 | 197                  | 156            | 236                         |
| # Some concern           | 214               | 164                     | 190                 | 229                  | 185            | 160                         |
| # Great concern          | 362               | 401                     | 332                 | 210                  | 295            | 240                         |
| Personality and sentiment features | 0.63      | 0.6                     | 0.54                | 0.58                 | 0.58           | 0.58                        |
| Word vectors             | **0.78**          | **0.78**                | **0.73**            | **0.71**             | **0.71**       | **0.71**                    |
| All features             | 0.64              | 0.62                    | 0.52                | 0.58                 | 0.58           | 0.58                        |

### Supplementary Table 3. Prediction results for lifestyle behaviours using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                          | Amount of physical activity | Shopping | Diet | Alcohol | Sleep | Smoking | E-cigarettes | Recreational drugs |
|--------------------------|-----------------------------|----------|------|---------|-------|---------|--------------|---------------------|
| # Decrease / Little impact |                            | 47       | 302  | 96      | 385   | 293     | 5            | 2                   | 3                   |
| # No change / Some impact |                            | 90       | 205  | 372     | 99    | 157     | 623          | 624                 | 628                 |
| # Increase / Great impact |                            | 499      | 129  | 168     | 152   | 186     | 8            | 10                  | 5                   |
| Personality and sentiment features |                    | 0.56     | 0.62 | 0.61    | 0.65  | 0.65    | 0.44         | 0.55                | 0.36                |
| Word vectors             |                            | **0.81** | **0.74** | **0.72** | **0.8** | **0.75** | **0.6** | **0.67** | 0.45               |
| All features             |                            | 0.55     | 0.6  | 0.56    | 0.61  | 0.65    | 0.58         | 0.58                | **0.53**            |
### Supplementary Table 4

Prediction results for depression (Patient Health Questionnaire, PHQ-9) and wellbeing score (Warwick-Edinburgh Mental Well-being Scale, WEMWBS) using three feature groups and evaluated using mean absolute error and explained variance. The best performing feature group is in bold.

|                              | Depression score (PHQ-9) | Wellbeing score (WEMWBS) |
|------------------------------|--------------------------|--------------------------|
| # participants               |                          |                          |
| Personality and sentiment    | 584                      | 636                      |
| features, MAE                | 4.25                     | 7.97                     |
| Personality and sentiment    |                          |                          |
| features, Exp. Var.          | 0.15                     | 0.17                     |
| Word vectors, MAE            | 4.52                     | 8.6                      |
| Word vectors, Exp. Var.      | 0.07                     | 0.1                      |
| All features, MAE            | 4.33                     | 8.15                     |
| All features, Exp. Var.      | 0.12                     | 0.13                     |
**Supplementary Table 5.** Impact of COVID-19 on Lifestyle Related Behaviours

| Changes to shopping behaviour | OR (95% CI) |
|-------------------------------|-------------|
| Chronic kidney disease | Yes | 1.62 (1.01, 2.60) |
| | No | 1.00 |
| Gender | Female | 1.18 (1.02, 1.38) |
| | Male | 1.00 |

| Changes to diet | OR (95% CI) |
|-----------------|-------------|
| Gender | Female | 1.19 (1.02, 1.39) |
| | Male | 1.00 |
| Age | 0.99 (0.98, 1.00) |
| BMI | 1.02 (1.00, 1.03) |

| Change to activity amount | OR (95% CI) |
|---------------------------|-------------|
| Chronic respiratory disease | Yes | 0.70 (0.50, 0.97) |
| | No | 1.00 |
| Chronic kidney disease | Yes | 0.65 (0.44, 0.96) |
| | No | 1.00 |
| Weakened immune system | Yes | 0.54 (0.37, 0.78) |
| | No | 1.00 |
| BMI | 0.98 (0.97, 1.00) |

| Changes to activity type | OR (95% CI) |
|--------------------------|-------------|
| Chronic neurological conditions | Yes | 0.23 (0.06, 1.00) |
| | No | 1.00 |
**Supplementary Table 6** Median wellbeing (Warwick-Edinburgh Mental Well-being Scale, WEMWBS) and depression (Patient Health Questionnaire, PHQ-9) scores based on high risk group.

|                               | Wellbeing Median [Min, Max] | Depression Median [Min, Max] |
|-------------------------------|-----------------------------|-----------------------------|
| **Diabetes**                  |                             |                             |
| Yes                           | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| No                            | 46.0 [14.0, 70.0]           | 7.00 [0, 26.0]              |
| **BMI ≥ 40 kg/m²**            |                             |                             |
| Yes                           | 40.6 [15.0, 70.0]           | 10.00 [0, 26.0]             |
| No                            | 46.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Chronic Respiratory Disease**|                             |                             |
| Yes                           | 43.5 [14.0, 70.0]           | 9.00 [0, 26.0]              |
| No                            | 46.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Chronic Heart Disease**     |                             |                             |
| Yes                           | 47.4 [14.0, 70.0]           | 7.00 [0, 26.0]              |
| No                            | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Chronic Kidney Disease**    |                             |                             |
| Yes                           | 47.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| No                            | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Chronic Liver Disease**     |                             |                             |
| Yes                           | 43.0 [15.0, 62.0]           | 7.00 [0, 22.0]              |
| No                            | 46.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Chronic Neurological Conditions** |                       |                             |
| Yes                           | 46.2 [19.0, 66.0]           | 8.00 [0, 22.0]              |
| No                            | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Spleen problems**           |                             |                             |
| Yes                           | 46.0 [26.0, 66.0]           | 5.00 [2.0, 13.0]            |
| No                            | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
| **Weakened immune system**    |                             |                             |
| Yes                           | 46.0 [14.0, 68.0]           | 6.00 [0, 26.0]              |
| No                            | 45.0 [14.0, 70.0]           | 6.00 [0, 26.0]              |
|                                | Yes         | No         |
|--------------------------------|-------------|------------|
| **Aged > 70 years**            |             |            |
| Yes                            | 51.0 [14.0, 70.0] | 3.00 [0, 26.0] |
| No                             | 44.0 [14.0, 70.0] | 7.00 [0, 26.0] |
| **Pregnant**                   |             |            |
| Yes                            | 42.0 [29.0, 61.0] | 6.00 [0, 17.0] |
| No                             | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Other risk factors** *       |             |            |
| Yes                            | 44.0 [14.0, 70.0] | 8.00 [0, 26.0] |
| No                             | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |

* Changed type or frequency of support
**Supplementary Table 7. Impact on Management of Health Conditions and Use of Technology**

| Changes to management of health conditions | OR (95% CI) |
|-------------------------------------------|-------------|
| Chronic liver disease                     |             |
| Yes                                       | 3.15 (1.29, 8.01) |
| No                                        | 1.00        |
| Changes to appointments                   |             |
| Diabetes                                  |             |
| Yes                                       | 2.40 (1.11, 5.75) |
| No                                        | 1.00        |
| Chronic liver disease                     |             |
| Yes                                       | 3.48 (1.16, 12.16) |
| No                                        | 1.00        |
| Weakened immune system                    |             |
| Yes                                       | 2.90 (1.18, 7.93) |
| No                                        | 1.00        |
| Changes to medication                     |             |
| Spleen problems                           |             |
| Yes                                       | 7.10 (1.45, 53.03) |
| No                                        | 1.00        |
| Changes to elective surgery               |             |
| Age                                       |             |
| Yes                                       | 1.03 (1.01, 1.06) |
| No                                        | 1.00        |
| Clinician                                 |             |
| Age                                       |             |
| Yes                                       | 1.03 (1.01, 1.05) |
| No                                        | 1.00        |
| Other changes                             |             |
| Aged > 70 years                           |             |
| Yes                                       | 0.24 (0.05, 0.88) |
| No                                        | 1.00        |
| Platforms used to receive care            |             |
| Social media                              |             |
| Chronic liver disease                     |             |
| Yes                                       | 5.91 (1.62, 20.84) |
| No                                        | 1.00        |
| Email                                     |             |
| Age                                       |             |
| Yes                                       | 0.98 (0.96, 1.00) |
| No                                        | 1.00        |
| Telephone                                 |             |
| Aged > 70 years                           |             |
| Yes                                       | 0.46 (0.21, 0.99) |
| No                                        | 1.00        |
| Virtual consultation                      |             |
| Chronic liver disease                     |             |
| Yes                                       | 4.39 (1.41, 13.20) |
| Chronic neurological conditions | No | 1.00 |
|--------------------------------|----|------|
|                                | Yes| 3.56 (1.06, 10.98) |
|                                | No | 1.00 |
| Gender                         | No | 1.00 |
|                                | Yes| 0.56 (0.32, 0.98) |
|                  | Diabetes (N=538) | BMI ≥ 40 kg/m² (N=142) | Chronic Respiratory Disease (N=179) | Chronic Heart Disease (N=132) | Chronic Kidney Disease (N=147) | Chronic Liver Disease (N=49) | Chronic Neurological Disease (N=35) | Spleen Problems (N=16) | Weakened Immune System > 70 years (N=178) | Aged > 70 years (N=178) | Pregnant (N=21) | Other Risk Factors (N=303) |
|------------------|------------------|------------------------|-------------------------------------|-------------------------------|------------------------------|-----------------------------|-----------------------------|------------------------|----------------------------------------|------------------------|----------------|---------------------------|
| Social distancing n (%) |                  |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 446 (82.9%)      | 105 (73.9%)            | 125 (69.8%)                         | 90 (68.2%)                    | 82 (55.8%)                   | 32 (65.3%)                  | 26 (74.3%)                  | 9 (56.2%)               | 71 (44.7%)                               | 135 (75.8%)             | 18 (85.7%)   |                        |
| No               | 92 (17.1%)       | 37 (26.1%)             | 54 (30.2%)                          | 42 (31.8%)                    | 65 (44.2%)                   | 17 (34.7%)                  | 9 (25.7%)                   | 7 (43.8%)               | 88 (55.3%)                               | 43 (24.2%)              | 3 (14.3%)     |                        |
| Self-isolation n (%) |                |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 263 (48.9%)      | 68 (47.9%)             | 83 (46.4%)                          | 58 (43.9%)                    | 66 (44.9%)                   | 19 (38.8%)                  | 21 (60.0%)                  | 7 (43.8%)               | 61 (38.4%)                               | 102 (57.3%)             | 10 (47.6%)   | 148 (48.8%)               |
| No               | 275 (51.1%)      | 74 (52.1%)             | 96 (53.6%)                          | 74 (56.1%)                    | 81 (55.1%)                   | 30 (61.2%)                  | 14 (40.0%)                  | 9 (56.2%)               | 98 (61.6%)                               | 76 (42.7%)              | 11 (52.4%)   | 155 (51.2%)               |
| Worn protective apparel n (%) |                  |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 201 (37.4%)      | 47 (33.1%)             | 59 (33.0%)                          | 44 (33.3%)                    | 30 (20.4%)                   | 17 (34.7%)                  | 13 (37.1%)                  | 1 (6.2%)                | 22 (13.8%)                               | 57 (32.0%)              | 6 (28.6%)     | 106 (35.0%)               |
| No               | 337 (62.6%)      | 95 (66.9%)             | 120 (67.0%)                         | 88 (66.7%)                    | 117 (79.6%)                  | 32 (65.3%)                  | 22 (62.9%)                  | 15 (93.8%)              | 137 (86.2%)                               | 121 (68.0%)             | 15 (71.4%)    | 197 (65.0%)               |
| Used online shopping or food delivery n (%) |                  |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 258 (48.0%)      | 67 (47.2%)             | 77 (43.0%)                          | 66 (50.0%)                    | 60 (40.8%)                   | 28 (57.1%)                  | 18 (51.4%)                  | 7 (43.8%)               | 55 (34.6%)                               | 96 (53.9%)              | 10 (47.6%)   | 125 (41.3%)               |
| No               | 280 (52.0%)      | 75 (52.8%)             | 102 (57.0%)                         | 66 (50.0%)                    | 87 (59.2%)                   | 21 (42.9%)                  | 17 (48.6%)                  | 9 (56.2%)               | 104 (65.4%)                               | 82 (46.1%)              | 11 (52.4%)    | 178 (58.7%)               |
| Shielding n (%) |                  |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 100 (18.6%)      | 33 (23.2%)             | 65 (36.3%)                          | 38 (28.8%)                    | 68 (46.3%)                   | 22 (44.9%)                  | 6 (17.1%)                   | 11 (68.8%)              | 85 (53.5%)                               | 38 (21.3%)              | 2 (9.5%)      | 80 (26.4%)                |
| No               | 438 (81.4%)      | 109 (76.8%)            | 114 (63.7%)                         | 94 (71.2%)                    | 79 (53.7%)                   | 27 (55.1%)                  | 29 (82.9%)                  | 5 (31.2%)               | 74 (46.5%)                               | 140 (78.7%)             | 19 (90.5%)    | 223 (73.6%)               |
| All of the above n (%) |                |                        |                                     |                               |                              |                             |                             |                        |                                        |                        |               |                           |
| Yes              | 55 (10.2%)       | 19 (13.4%)             | 22 (12.3%)                          | 23 (17.4%)                    | 31 (21.1%)                   | 7 (14.3%)                   | 4 (11.4%)                   | 2 (12.5%)               | 40 (25.2%)                               | 29 (16.3%)              | 2 (9.5%)      | 46 (15.2%)                |
| No               | 483 (89.8%)      | 123 (86.6%)            | 157 (87.7%)                         | 109 (82.6%)                   | 116 (78.9%)                  | 42 (85.7%)                  | 31 (88.6%)                  | 14 (87.5%)              | 119 (74.8%)                               | 149 (83.7%)             | 19 (90.5%)    | 257 (84.8%)               |
## Supplementary Table 9. Mitigating COVID-19

| Mitigating Risk Actions | Weakened immune system | Diabetes | Chronic liver disease | Chronic kidney disease | Spleen problems | Protective apparel | Shop online | Shielding | All mitigating risk actions |
|-------------------------|------------------------|---------|----------------------|------------------------|-----------------|--------------------|-------------|----------|-----------------------------|
| Social distancing       |                        |         |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 0.34 (0.16, 0.73) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 2.44 (1.25, 4.90) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
| Protective apparel      |                        | 2.17 (1.13, 4.14) |                      |                        |                 |                    |             |          |                             |
|                         |                        | 1.00     |                      |                        |                 |                    |             |          |                             |
| Shop online             |                        |          |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 2.66 (1.24, 5.88) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 3.34 (1.42, 8.14) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
| Shielding               |                        |          |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 2.76 (1.21, 6.31) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 3.33 (1.55, 7.22) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 5.33 (1.15, 28.78) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
| All mitigating risk actions |                    |          |                      |                        |                 |                    |             |          |                             |
|                         | Yes                    | 2.61 (1.01, 6.41) |                      |                        |                 |                    |             |          |                             |
|                         | No                     | 1.00     |                      |                        |                 |                    |             |          |                             |
Supplementary Figure 1. Change in diet compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 2. Change in alcohol consumption compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 3. Change in amount of physical activity compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 4. Change in type of physical activity compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 5. Change in amount or quality of sleep compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 6. Change in shopping compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 7: Concern about becoming infected with COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 8: Concern about severe illness and possible death from COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
**Supplementary Figure 9:** Concern about spreading COVID-19 to others including family and friends for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

**Supplementary Figure 10:** Concern about access to healthcare support for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
**Supplementary Figure 11:** Concern about access to appropriate care if infected with COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

**Supplementary Figure 12:** Concern about disparate care as a result of high-risk status for each indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary materials

1. Awareness, Attitudes and Actions (AAA) survey
2. Supplementary data analysis
3. Statistics tables and figures
4. AI prediction models
Awareness, Attitudes and Actions (AAA) survey

| Survey questions                                                                 | Response categories/instruction                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Section A: demographics**                                                      |                                                                                                                                                                                                                                |
| Does any of the following apply to you? (select all that apply)                  | Diabetes (Type 1 or 2)                                                                                                                                                                                                                                                                   |
|                                                                                 | A body mass index (BMI) of 40 or above                                                                                                                                                                                                                                                   |
|                                                                                 | Chronic (long-term) respiratory diseases, such as asthma, chronic obstructive pulmonary disease (COPD), emphysema or bronchitis                                                                                                                                                          |
|                                                                                 | Chronic heart disease, such as heart failure                                                                                                                                                                                                                                                |
|                                                                                 | Chronic kidney disease                                                                                                                                                                                                                                                                    |
|                                                                                 | Chronic liver disease, such as hepatitis                                                                                                                                                                                                                                                   |
|                                                                                 | Chronic neurological conditions, such as Parkinson’s disease, motor neurone disease, multiple sclerosis (MS), a learning disability or cerebral palsy                                                                                                                                 |
|                                                                                 | Problems with your spleen – for example, sickle cell disease or if you have had your spleen removed                                                                                                                                                                                     |
|                                                                                 | A weakened immune system as the result of conditions such as HIV and AIDS, or medicines such as steroid tablets or chemotherapy                                                                                                                                                       |
|                                                                                 | None of these apply to me                                                                                                                                                                                                                                                                  |
|                                                                                 | I have a different long term health condition not listed above (please specify in the text box provided)                                                                                                                                                                                      |
| Please state your age                                                           | Textbox                                                                                                                                                                                                                                                                          |
| Gender                                                                          | Male                                                                                                                                                                                                                                                                             |
|                                                                                 | Female                                                                                                                                                                                                                                                                            |
|                                                                                 | Other (textbox)                                                                                                                                                                                                                                                                     |
|                                                                                 | Prefer not to say                                                                                                                                                                                                        |
| What is your ethnicity?                                                          | White – British, Irish, other Asian/Asian British – Indian, Pakistani, Bangladeshi, other Chinese/Chinese British Black/Black British – Caribbean, African, other Middle Eastern/Middle Eastern British – Arab, Turkish, other Mixed race – White and Black/Black British Mixed race – other Other ethnic groups (please specify in the text box provided) Prefer not to say |
| What is your height in feet and inches, or centimetres?                         | Text box provided for each                                                                                                                                                                                                 |
| What is your weight in pounds or kilograms?                                      | Text box provided for each                                                                                                                                                                                                 |
| Question                                                                 | Response                                                                 |
|-------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Do you work in health or social care?                                   | Yes (please provide your job title in the text box)                       |
| Does your job require you to be in direct contact with coronavirus (COVID-19) patients? | Yes / No                                                                 |
| Please provide the first half of your postcode (e.g. NG1)               | Textbox provided                                                          |
| Please provide your email address                                       | Textbox provided                                                          |
| **Section B: awareness, attitudes and actions relating to COVID-19**    |                                                                          |
| Have you had coronavirus?                                               | Yes – I have been diagnosed and am still ill                             |
|                                                                         | Yes – I have and I have recovered                                        |
|                                                                         | Yes - I have been diagnosed, but had no symptoms                          |
|                                                                         | No                                                                       |
| Have you experienced coronavirus symptoms?                              | Yes - and I was diagnosed                                                 |
|                                                                         | Yes – but I have not been diagnosed                                       |
|                                                                         | No                                                                       |
|                                                                         | I don’t know what the symptoms                                            |
| Which of the below are symptoms of coronavirus? (Select all that is relevant) | Persistent cough                                 |
|                                                                         | Feeling confused                                                           |
|                                                                         | Loss of appetite                                                           |
|                                                                         | Loss of smell                                                              |
|                                                                         | Loss of taste                                                              |
|                                                                         | Tightness in chest                                                         |
|                                                                         | Diarrhoea                                                                 |
|                                                                         | Fatigue                                                                    |
|                                                                         | Shortness of breath                                                        |
|                                                                         | Fever                                                                     |
|                                                                         | Sore throat                                                                |
|                                                                         | None of the above                                                          |
| Have you taken any of the actions below in response to the coronavirus (COVID-19) outbreak? (select all that apply) | Social distancing                                                        |
|                                                                         | Self-isolation                                                             |
|                                                                         | Worn protective apparel (e.g. gloves, mask etc.)                            |
|                                                                         | Used online shopping or food delivery service                               |
|                                                                         | Shielding due as my health status means I am defined as 'extremely vulnerable' |
|                                                                         | All of the above                                                           |
|                                                                         | Other (Textbox)                                                            |
| Do you believe you are at higher risk of severe illness from coronavirus (COVID-19)? | Yes / No                                                                  |
| Why do you believe you are at a higher risk of severe illness from coronavirus (COVID-19)? (only for those who answered yes) | Textbox                                                                   |
| Why do you believe you are not at a higher risk of severe illness from coronavirus (COVID-19)? (only for those who answered no) | Textbox                                                                   |
| Question                                                                                           | Option      |
|---------------------------------------------------------------------------------------------------|-------------|
| Describe how being identified as being at a higher risk of severe illness from coronavirus (COVID-19) by the UK Government, has made you feel? | Textbox     |
| What sources have informed you that you are at a higher risk from coronavirus (COVID-19)? (select all that apply) | Traditional media (TV, Newspapers, Radio)  
Social media (Twitter, Facebook, Instagram, Snapchat)  
National or Local Government  
Employer  
Healthcare organisations  
Community groups  
Charity  
Friends and Family  
Schools and education centres  
Other (please specify in the text box provided) |
| Do you feel like you have enough information specific to your higher risk of severe illness from coronavirus (COVID-19)? | Yes  
No |
| Why do you believe you have received enough information specific to your higher risk of severe illness from coronavirus (COVID-19), and what more do you want to know? (only for those who answered yes) | Textbox     |
| Why do you believe you have not received enough information specific to your higher risk of severe illness from coronavirus (COVID-19), and what else do you want to know? (only for those who answered no) | Textbox     |
| Have you used other forms of information (i.e. nonprofessional/social media “experts”/other people/patients) since the COVID-19 outbreak? | Yes  
No |
| Please specify what information you have used relating to your higher risk status since the coronavirus (COVID19) outbreak | Textbox     |
| How concerned are you about each of the statements below | Likert scale from 0 (Not concerned at all) to 10 (Very concerned) |
| • Becoming infected with coronavirus (COVID-19)                                                         |             |
| • Severe illness and possibly death from coronavirus (COVID-19)                                       |             |
| • Spreading coronavirus (COVID-19) to others including family and friends                             |             |
| • Access to healthcare support (e.g. advice, medication)                                              |             |
| • If you become infected, that you would receive appropriate care/support                             |             |
| • That your higher risk of severe illness from coronavirus (COVID-19) means you may not               |             |
**receive healthcare support compared with people who do not have a higher risk status**

| **Section C: impact of COVID-19 on management of health conditions and use of technology** |
| --- |
| **Has your management of your health condition changed compared to before the coronavirus (COVID-19) outbreak?** | Yes  
No  
Not applicable (70 years or over or pregnant without a health condition) |
| **How and why has it changed?** | Textbox |
| **How do you feel about changing your management of your health condition due to the coronavirus (COVID-19) outbreak?** | Textbox |
| **Has COVID-19 changed your regular healthcare support? (this could type or frequency of support e.g. appointments, service, medications, communication consultant)** | Appointments (please specify in the text box)  
Medication (please specify in the text box)  
Elective surgery (please specify in the text box)  
Communication platform (please specify in the text box)  
Clinician caring for me (please specify in the text box)  
Other (please specify in the text box)  
There has been no change |
| **Have you received care through any of the following platforms?** | Social media (please specify in the text box)  
Mobile phone app (please specify in the text box)  
Email  
Telephone Virtual consultation e.g. Zoom, Microsoft Teams (please specify in the text box)  
Other (please specify in the text box)  
No platforms have been used  
I am still receiving face to face care |
| **How satisfied are you with using the platforms that you are receiving care through?** | Extremely dissatisfied  
Somewhat dissatisfied  
Neither satisfied nor dissatisfied  
Somewhat satisfied  
Extremely satisfied |
| **How satisfied are you with using the information/resources provided through the platforms that you are receiving care through?** | Extremely dissatisfied  
Somewhat dissatisfied  
Neither satisfied nor dissatisfied  
Somewhat satisfied  
Extremely satisfied |
| **Would you welcome the continued use of these platforms in the future, after the coronavirus (COVID-19) outbreak?** | Yes  
No, but would welcome other platforms (please specify in the text box)  
No  
Not sure, I need more time to use them |
You indicated that you have more than one of the high risk indicator for severe illness from coronavirus (COVID19). Please describe how this makes you feel, and why?

### Section D: Mental Health and Wellbeing

Since the coronavirus (COVID-19) outbreak, my mental health is

| Yes | No |
|-----|----|

Warwick-Edinburgh Mental Well-being Scale (WEMWBS)

**During the past two weeks...**

- I’ve been feeling optimistic about the future
- I’ve been feeling useful
- I’ve been feeling relaxed
- I’ve been feeling interested in other people
- I’ve had energy to spare
- I’ve been dealing with problems well
- I’ve been thinking clearly
- I’ve been feeling good about myself
- I’ve been feeling close to other people
- I’ve been feeling confident
- I’ve been able to make up my own mind about things
- I’ve been feeling loved
- I’ve been interested in new things
- I’ve been feeling cheerful

WARWICK-EDINBURGH MENTAL WELL-BEING SCALE (WEMWBS)

**Not at all**

**Rarely**

**Some of the time**

**Often**

**All of the time**

Patient Health Questionnaire (PHQ-9)

**Over the last two weeks, how often have you been bothered by any of the following problems?**

- Little interest or pleasure in doing things?
- Feeling down, depressed, or hopeless?
- Trouble falling or staying asleep, or sleeping too much?
- Feeling tired or having little energy?
- Poor appetite or overeating?
- Feeling bad about yourself - or that you are a failure or have let yourself or your family down?
- Trouble concentrating on things, such as reading the newspaper or watching television?
- Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual?
- Thoughts that you would be better off dead, or of hurting yourself in some way?

**Not at all**

**Several days**

**More than half the days**

**Nearly every day**

### Section D: lifestyle related behaviours

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| Has your shopping changed since the coronavirus (COVID-19) outbreak? | A great deal  
A lot  
A moderate amount  
A little  
Not at all |
|---|---|
| Describe how your shopping has changed since the coronavirus (COVID-19) outbreak | Textbox |
| Has your diet changed since the coronavirus (COVID-19) outbreak? | A great deal  
A lot  
A moderate amount  
A little  
Not at all |
| Describe how your diet has changed since the coronavirus (COVID-19) outbreak | Textbox |
| Has your alcohol consumption changed since the coronavirus outbreak? | I have consumed much less alcohol than usual  
I have consumed less alcohol than usual  
It hasn't changed  
I have consumed more alcohol than usual  
I have consumed much more alcohol than usual |
| Why has your alcohol consumption changed since the coronavirus (COVID-19) outbreak? | Textbox |
| Has the amount of physical activity you usually engage in changed since the coronavirus outbreak? | I am much less active  
I am less active  
It hasn't changed  
I am more active  
I am much more active |
| Has the type of physical activity you usually engage in changed since the coronavirus outbreak? | Yes  
No |
| Describe how and why your physical activity has changed since the coronavirus outbreak | Textbox |
| Has the amount or quality of your sleep changed since the coronavirus outbreak? | A great deal  
A lot  
A moderate amount  
A little  
Not at all |
| Describe how and why the amount or quality of your sleep has changed since the coronavirus outbreak | Textbox |
| Do you smoke tobacco? | Yes  
No |
| Has the amount of tobacco you smoke changed compared to before the coronavirus (COVID-19) outbreak? | Much more  
Somewhat more  
About the same  
Somewhat less  
Much less |
| Do you use e-cigarettes? | Yes  
No |
Has the amount of e-cigarettes you use changed compared to before the coronavirus (COVID19) outbreak?

| Much more      | Somewhat more | About the same | Somewhat less | Much less |
|----------------|---------------|----------------|---------------|-----------|

Other than alcohol or tobacco, do you use any recreational drugs?

| Yes | No |
|-----|----|

Has the amount of recreational drugs you use changed compared to before the coronavirus (COVID19) outbreak?

| Much more      | Somewhat more | About the same | Somewhat less | Much less |
|----------------|---------------|----------------|---------------|-----------|

**Section E: Interaction with others**

For the following questions, please respond with your health condition or higher risk status (70 years old or over or pregnant regardless of medical conditions) in mind. Since the coronavirus (COVID-19) outbreak...

Other people have behaved differently towards you?

| Yes | No |
|-----|----|

Describe how and why people have behaved differently towards you since the COVID-19 outbreak?

| Textbox |
|---------|

You felt stigmatised or discriminated against?

| Yes | No |
|-----|----|

Describe the stigmatising and/or discriminatory experience(s) you have had since the COVID-19 outbreak, and how this has made you feel?

| Textbox |
|---------|

**Final section**

Is there anything that you haven’t had chance to say about the coronavirus outbreak that you would like to share?

| Textbox |
|---------|
**Supplementary Data analysis**

**Text Data**

Text data was collected across 17 open-ended questions which were distributed throughout the survey sections. All responses to open-ended questions were concatenated, yielding a language sample for each survey participant, which was then tokenised using spaCy’s large English web model[^1]. The length of the concatenated responses (i.e. the number of tokens, including words, digits, and punctuation) varied from 1 to 2125 tokens (mean=184, median=135). The language sample for each participant was further processed to derive sentiment scores and personality scores. VADER Sentiment Analysis tool (Hutto & Gilbert, 2014) was used to obtain sentiment scores (positive, neutral, negative, and compound sentiment). Personality scores were obtained using proprietary software by Scaled Insights. The software takes as input a language sample and produces 114 personality features. Following this, the 118 features (114 personality, 4 sentiment) were used as input into the multiple machine learning models described below. As the reliability of the personality modelling software depends on the number of words provided in the language sample, the following analysis was restricted to participants (N=636) whose combined text response consisted of at least 100 tokens. The machine learning was used in two settings: unsupervised (clustering) and supervised (classification or regression).

In addition to the clustering, we investigated to what extent features obtained from a language sample could be used for predicting concerns, mitigating actions, impact on lifestyle behaviours, and wellbeing and depression scores in the context of COVID-19. A model which predicts these attitudes and behaviours and requires only a language sample could potentially be used within a digital environment to better identify people who might be more likely to be negatively impacted and offer them preventative support.

For each attitude or behaviour we trained a separate binary or multi-class classifier. We first explored a range of different classifiers (logistic regression, support vector machine, stochastic gradient descent classifier, and Random Forest). Across all classifiers we found that Random Forest achieved the best results, and we tuned the parameters for each classifier separately. The tuned parameters were then used to train the final classifiers using 10-fold cross-validation. As there were only sufficient language samples for 636 participants, we also trained classifiers using GloVe word vectors obtained from the same language model as the tokens. By using word vectors, we were able to train prediction models using all participants’ data.

All classification problems were evaluated using the Area Under the Receiver Operating Characteristics (AUROC) metric, while regression problems were evaluated using Mean Absolute Error (MAE) and explained variance.

[^1]: https://spacy.io/models/en#en_core_web_lg
**Prediction models**

**Concerns about COVID-19**

The responses relating to concerns were all expressed on a [1,10] scale. To form classes, the values were split into ‘slight’ (1-3), ‘some’ (4-7) and ‘great’ (8-10). Word vectors achieved the best performance with AUROC ranging from 0.71 to 0.78; see Supplementary Table 3.

**Mitigating COVID-19**

The mitigating actions each formed a binary class (i.e. someone either used particular mitigation action or not). Best performance was achieved by word vectors with AUROC ranging between 0.67 and 0.82. In the case of a more unbalanced class (predicting someone taking all possible mitigating actions), the best AUROC score (0.68) was achieved by personality and sentiment features; see Supplementary Table 2.

**Impact of COVID-19 on Health and Lifestyle Related Behaviours**

The responses on the impact of COVID-19 on lifestyle behaviours, used scales which were converted to classes as follows. Scale [-2,2] (used for alcohol consumption, physical activity, smoking, e-cigarettes, and recreational drug use) was converted to ‘Decrease’ [-2,-1], ‘No Change’ [0], ‘Increase’ [1,2]. Scale [0,4] (used for shopping, diet and sleep) was converted to ‘No or little impact’ [0,1], ‘Some impact’ [2], ‘Great impact’ [3,4]. For the lifestyle behaviours which were not well represented in the survey cohort (smoking, e-cigarettes, and recreational drug use) the results are very low (AUROC slightly better than random at 0.53 for recreational drug use). The best classifiers for other lifestyle behaviours had AUROC scores between 0.72 and 0.81; see Supplementary Table 4.

**Impact of COVID-19 on Wellbeing**

The scores for WEMWBS and PHQ-9 for both measures were used directly as target variables in the regression models. Unlike the prediction models reported previously, for both wellbeing and depression scores the best performing models used personality and sentiment scores. The model for depression achieved MAE = 4.25 and explained variance of 0.15, while the wellbeing model achieved MAE=7.97 and explained variance of 0.17; see Supplementary Table 5.

**Supplementary Table 1.** Prediction results for mitigating actions using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                  | Social distancing | Self-isolation | PPE | Online shopping | Shielding | All above |
|------------------|-------------------|----------------|-----|-----------------|-----------|-----------|
| # positive class | 491               | 306            | 208 | 304             | 173       | 77        |
| # negative class | 145               | 330            | 428 | 332             | 463       | 559       |
| Personality and  | 0.66              | 0.55           | 0.51| 0.49            | 0.62      | **0.68**  |
| sentiment features|                  |                |     |                 |           |           |
| Word vectors     | **0.82**          | **0.7**        | **0.67**| **0.68**       | **0.73**  | 0.54      |
| All features     | 0.71              | 0.58           | 0.51| 0.52            | 0.69      | 0.67      |
**Supplementary Table 2.** Prediction results for concerns using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                  | Becoming infected | Severe illness or death | Spreading to others | Access to healthcare | Enough support | Less care compared to low risk |
|------------------|-------------------|-------------------------|---------------------|---------------------|----------------|-------------------------------|
| # Slight concern | 60                | 71                      | 114                 | 197                 | 156            | 236                           |
| # Some concern   | 214               | 164                     | 190                 | 229                 | 185            | 160                           |
| # Great concern  | 362               | 401                     | 332                 | 210                 | 295            | 240                           |
| Personality and sentiment features | 0.63          | 0.6                     | 0.54                | 0.58                | 0.58           | 0.58                          |
| Word vectors     | **0.78**          | **0.78**                | **0.73**            | **0.71**            | **0.71**       | **0.71**                      |
| All features     | 0.64              | 0.62                    | 0.52                | 0.58                | 0.58           | 0.58                          |

**Supplementary Table 3.** Prediction results for lifestyle behaviours using three feature groups and evaluated using AUROC. The best performing feature group is in bold.

|                  | Amount of physical activity | Sleep | Smoking | E-cigarettes | Recreational drugs |
|------------------|-----------------------------|-------|---------|--------------|--------------------|
|                  | Shopping Diet Alcohol       |       |         |              |                    |
| # Decrease / Little impact | 47 302 96 385 293 5 2 3          |       |         |              |                    |
| # No change / Some impact    | 90 205 372 99 157 623 624 628    |       |         |              |                    |
| # Increase / Great impact    | 499 129 168 152 186 8 10 5      |       |         |              |                    |
| Personality and sentiment features | 0.56 0.62 0.61 0.65 0.65 0.44 0.55 0.36 |       |         |              |                    |
| Word vectors          | **0.81** **0.74** **0.72** **0.8** **0.75** **0.6** **0.67** 0.45 |       |         |              |                    |
| All features          | 0.55 0.6 0.56 0.61 0.65 0.58 0.58 **0.53** |       |         |              |                    |
**Supplementary Table 4.** Prediction results for depression (Patient Health Questionnaire, PHQ-9) and wellbeing score (Warwick-Edinburgh Mental Well-being Scale, WEMWBS) using three feature groups and evaluated using mean absolute error and explained variance. The best performing feature group is in bold.

|                          | Depression score (PHQ-9) | Wellbeing score (WEMWBS) |
|--------------------------|--------------------------|---------------------------|
| **# participants**       | 584                      | 636                       |
| Personality and sentiment features, MAE | 4.25                     | 7.97                      |
| Personality and sentiment features, Exp. Var. | 0.15                     | 0.17                      |
| Word vectors, MAE        | 4.52                     | 8.6                       |
| Word vectors, Exp. Var. | 0.07                     | 0.1                       |
| All features, MAE       | 4.33                     | 8.15                      |
| All features, Exp. Var. | 0.12                     | 0.13                      |
### Supplementary Table 5. Impact of COVID-19 on Lifestyle Related Behaviours

|                                | OR (95% CI)               |
|--------------------------------|---------------------------|
| **Changes to shopping behaviour** |                           |
| Chronic kidney disease         |                           |
| Yes                            | 1.62 (1.01, 2.60)         |
| No                             | 1.00                      |
| Gender                         |                           |
| Female                         | 1.18 (1.02, 1.38)         |
| Male                           | 1.00                      |
| **Changes to diet**            |                           |
| Gender                         |                           |
| Female                         | 1.19 (1.02, 1.39)         |
| Male                           | 1.00                      |
| Age                            | 0.99 (0.98, 1.00)         |
| BMI                            | 1.02 (1.00, 1.03)         |
| **Change to activity amount**  |                           |
| Chronic respiratory disease    |                           |
| Yes                            | 0.70 (0.50, 0.97)         |
| No                             | 1.00                      |
| Chronic kidney disease         |                           |
| Yes                            | 0.65 (0.44, 0.96)         |
| No                             | 1.00                      |
| Weakened immune system         |                           |
| Yes                            | 0.54 (0.37, 0.78)         |
| No                             | 1.00                      |
| BMI                            | 0.98 (0.97, 1.00)         |
| **Changes to activity type**   |                           |
| Chronic neurological conditions |                           |
| Yes                            | 0.23 (0.06, 1.00)         |
| No                             | 1.00                      |
**Supplementary Table 6** Median wellbeing (Warwick-Edinburgh Mental Well-being Scale, WEMWBS) and depression (Patient Health Questionnaire, PHQ-9) scores based on high risk group.

| Wellbeing | Depression |
|-----------|------------|
| Median [Min, Max] | Median [Min, Max] |
| **Diabetes** | | |
| Yes | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| No | 46.0 [14.0, 70.0] | 7.00 [0, 26.0] |
| **BMI ≥ 40 kg/m^2** | | |
| Yes | 40.6 [15.0, 70.0] | 10.00 [0, 26.0] |
| No | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Chronic Respiratory Disease** | | |
| Yes | 43.5 [14.0, 70.0] | 9.00 [0, 26.0] |
| No | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Chronic Heart Disease** | | |
| Yes | 47.4 [14.0, 70.0] | 7.00 [0, 26.0] |
| No | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Chronic Kidney Disease** | | |
| Yes | 47.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| No | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Chronic Liver Disease** | | |
| Yes | 43.0 [15.0, 62.0] | 7.00 [0, 22.0] |
| No | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Chronic Neurological Conditions** | | |
| Yes | 46.2 [19.0, 66.0] | 8.00 [0, 22.0] |
| No | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Spleen problems** | | |
| Yes | 46.0 [26.0, 66.0] | 5.00 [2.0, 13.0] |
| No | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
| **Weakened immune system** | | |
| Yes | 46.0 [14.0, 68.0] | 6.00 [0, 26.0] |
| No | 45.0 [14.0, 70.0] | 6.00 [0, 26.0] |
### Aged > 70 years

|   | Yes       | 51.0 [14.0, 70.0] | 3.00 [0, 26.0] |
|---|-----------|--------------------|----------------|
|   | No        | 44.0 [14.0, 70.0] | 7.00 [0, 26.0] |

### Pregnant

|   | Yes       | 42.0 [29.0, 61.0] | 6.00 [0, 17.0] |
|---|-----------|--------------------|----------------|
|   | No        | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |

### Other risk factors *

|   | Yes       | 44.0 [14.0, 70.0] | 8.00 [0, 26.0] |
|---|-----------|--------------------|----------------|
|   | No        | 46.0 [14.0, 70.0] | 6.00 [0, 26.0] |

* *Changed type or frequency of support*
### Supplementary Table 7. Impact on Management of Health Conditions and Use of Technology

| Changes to management of health conditions                  | Chronic liver disease | Yes | 3.15 (1.29, 8.01) |
|------------------------------------------------------------|-----------------------|-----|------------------|
|                                                            | No                    |     | 1.00             |

| Changes to appointments                                     | Diabetes              | Yes | 2.40 (1.11, 5.75) |
|------------------------------------------------------------|-----------------------|-----|------------------|
|                                                            | No                    |     | 1.00             |

| Changes to appointments                                     | Chronic liver disease | Yes | 3.48 (1.16, 12.16) |
|------------------------------------------------------------|-----------------------|-----|------------------|
|                                                            | No                    |     | 1.00             |

| Changes to appointments                                     | Weakened immune system | Yes | 2.90 (1.18, 7.93) |
|------------------------------------------------------------|------------------------|-----|------------------|
|                                                            | No                     |     | 1.00             |

| Changes to medication                                      | Spleen problems        | Yes | 7.10 (1.45, 53.03) |
|------------------------------------------------------------|------------------------|-----|------------------|
|                                                            | No                     |     | 1.00             |

| Changes to elective surgery                                | Age                    |     | 1.03 (1.01, 1.06) |
|                                                            | Age                    |     | 1.03 (1.01, 1.05) |

| Changes to elective surgery                                | Aged > 70 years        | Yes | 0.24 (0.05, 0.88) |
|------------------------------------------------------------|------------------------|-----|------------------|
|                                                            | No                     |     | 1.00             |

| Platforms used to receive care                             | Social media           | Chronic liver disease | Yes | 5.91 (1.62, 20.84) |
|------------------------------------------------------------|------------------------|-----------------------|-----|------------------|
|                                                            | Email                  | Age                   |     | 0.98 (0.96, 1.00) |

| Platforms used to receive care                             | Telephone              | Aged > 70 years        | Yes | 0.46 (0.21, 0.99) |
|------------------------------------------------------------|------------------------|------------------------|-----|------------------|
|                                                            | Virtual consultation   | Chronic liver disease  | Yes | 4.39 (1.41, 13.20) |
| Chronic neurological conditions | Yes | 3.56 (1.06, 10.98) | No | 1.00 |
|---------------------------------|-----|--------------------|----|------|
| Gender                          | Yes | 0.56 (0.32, 0.98)  | No | 1.00 |
**Supplementary Table 8. Mitigating actions taken in response to the coronavirus outbreak.**

|                      | Diabetes (N=538) | BMI ≥ 40 kg/m² (N=142) | Chronic Respiratory Disease (N=179) | Chronic Heart Disease (N=132) | Chronic Kidney Disease (N=147) | Chronic Liver Disease (N=49) | Chronic Neurological Disease (N=35) | Spleen Problems (N=16) | Weakened Immune System > 70 years (N=178) | Aged > 70 years (N=178) | Pregnant (N=21) | Other Risk Factors (N=303) |
|----------------------|------------------|------------------------|-------------------------------------|-----------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------------|-----------------------------------------------|----------------------|----------------|---------------------------|
| Social distancing n (%) |                  |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 446 (82.9%)      | 105 (73.9%)            | 125 (69.8%)                         | 90 (68.2%)                  | 82 (55.8%)                    | 32 (65.3%)                    | 26 (74.3%)                    | 9 (56.2%)             | 71 (44.7%)                                      | 135 (75.8%)          | 18 (85.7%) | 212 (70.0%)               |
| No                   | 92 (17.1%)       | 37 (26.1%)             | 54 (30.2%)                          | 42 (31.8%)                  | 65 (44.2%)                    | 17 (34.7%)                    | 9 (25.7%)                     | 7 (43.8%)             | 88 (55.3%)                                      | 43 (24.2%)           | 3 (14.3%) | 91 (30.0%)                |
| Self-isolation n (%) |                  |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 263 (48.9%)      | 68 (47.9%)             | 83 (46.4%)                          | 58 (43.9%)                  | 66 (44.9%)                    | 19 (38.8%)                    | 21 (60.0%)                    | 7 (43.8%)             | 61 (38.4%)                                      | 102 (57.3%)          | 10 (47.6%) | 148 (48.8%)               |
| No                   | 275 (51.1%)      | 74 (52.1%)             | 96 (53.6%)                          | 74 (56.1%)                  | 81 (55.1%)                    | 30 (61.2%)                    | 14 (40.0%)                    | 9 (56.2%)             | 98 (61.6%)                                      | 76 (42.7%)           | 11 (52.4%) | 155 (51.2%)               |
| Worn protective apparel n (%) |              |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 201 (37.4%)      | 47 (33.1%)             | 59 (33.0%)                          | 44 (33.3%)                  | 30 (20.4%)                    | 17 (34.7%)                    | 13 (37.1%)                    | 1 (6.2%)              | 22 (13.8%)                                      | 57 (32.0%)           | 6 (28.6%) | 106 (35.0%)               |
| No                   | 337 (62.6%)      | 95 (66.9%)             | 120 (67.0%)                         | 88 (66.7%)                  | 117 (79.6%)                   | 32 (65.3%)                    | 22 (62.9%)                    | 15 (93.8%)            | 137 (86.2%)                                     | 121 (68.0%)          | 15 (71.4%) | 197 (65.0%)               |
| Used online shopping or food delivery n (%) |              |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 258 (48.0%)      | 67 (47.2%)             | 77 (43.0%)                          | 66 (50.0%)                  | 60 (40.8%)                    | 28 (51.7%)                    | 18 (51.4%)                    | 7 (43.8%)             | 55 (34.6%)                                      | 96 (53.9%)           | 10 (47.6%) | 125 (41.3%)               |
| No                   | 280 (52.0%)      | 75 (52.8%)             | 102 (57.0%)                         | 66 (50.0%)                  | 87 (59.2%)                    | 21 (42.9%)                    | 17 (48.6%)                    | 9 (56.2%)             | 104 (65.4%)                                     | 82 (46.1%)           | 11 (52.4%) | 178 (58.7%)               |
| Shielding n (%)      |                  |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 100 (18.6%)      | 33 (23.2%)             | 65 (36.3%)                          | 38 (28.8%)                  | 68 (46.3%)                    | 22 (44.9%)                    | 6 (17.1%)                     | 11 (68.8%)            | 85 (53.5%)                                      | 38 (21.3%)           | 2 (9.5%)   | 80 (26.4%)                |
| No                   | 438 (81.4%)      | 109 (76.8%)            | 114 (63.7%)                         | 94 (71.2%)                  | 79 (53.7%)                    | 27 (55.1%)                    | 29 (82.9%)                    | 5 (31.2%)             | 74 (46.5%)                                      | 140 (78.7%)          | 19 (90.5%) | 223 (73.6%)               |
| All of the above n (%) |                |                        |                                     |                             |                               |                               |                               |                       |                                                              |                      |                |                           |
| Yes                  | 55 (10.2%)       | 19 (13.4%)             | 22 (12.3%)                          | 23 (17.4%)                  | 31 (21.1%)                    | 7 (14.3%)                     | 4 (11.4%)                     | 2 (12.5%)             | 40 (25.2%)                                      | 29 (16.3%)           | 2 (9.5%)   | 46 (15.2%)                |
| No                   | 483 (89.8%)      | 123 (86.6%)            | 157 (87.7%)                         | 109 (82.6%)                 | 116 (78.9%)                   | 42 (85.7%)                    | 31 (88.6%)                    | 14 (87.5%)            | 119 (74.8%)                                     | 149 (83.7%)          | 19 (90.5%) | 257 (84.8%)               |
| **Supplementary Table 9. Mitigating COVID-19** |
|-----------------------------------------------|
| **OR (95% CI)**                               |
| **Social distancing**                         |
| Weakened immune system | Yes | 0.34 (0.16, 0.73) |
| No | 1.00 |
| Diabetes | Yes | 2.44 (1.25, 4.90) |
| No | 1.00 |
| **Protective apparel**                        |
| Diabetes | Yes | 2.17 (1.13, 4.14) |
| No | 1.00 |
| **Shop online**                               |
| Aged > 70 years | Yes | 2.66 (1.24, 5.88) |
| No | 1.00 |
| Chronic liver disease | Yes | 3.34 (1.42, 8.14) |
| No | 1.00 |
| **Shielding**                                 |
| Chronic kidney disease | Yes | 2.76 (1.21, 6.31) |
| No | 1.00 |
| Weakened immune system | Yes | 3.33 (1.55, 7.22) |
| No | 1.00 |
| Spleen problems | Yes | 5.33 (1.15, 28.78) |
| No | 1.00 |
| **All mitigating risk actions**               |
| Weakened immune system | Yes | 2.61 (1.01, 6.41) |
| No | 1.00 |
Supplementary Figure 1. Change in diet compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 2. Change in alcohol consumption compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 3. Change in amount of physical activity compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 4. Change in type of physical activity compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 5. Change in amount or quality of sleep compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 6. Change in shopping compared to pre-COVID-19 for each high-risk indicator of severe illness from COVID-19 as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 7: Concern about becoming infected with COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 8: Concern about severe illness and possible death from COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 9: Concern about spreading COVID-19 to others including family and friends for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 10: Concern about access to healthcare support for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.
Supplementary Figure 11: Concern about access to appropriate care if infected with COVID-19 for each high-risk indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.

Supplementary Figure 12: Concern about disparate care as a result of high-risk status for each indicator as identified by the UK Government, or based on individual perception due to an acute or chronic health condition.