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Mental health in the UK during the COVID-19 pandemic: Cross-sectional analyses from a community cohort study

Brief title: Mental Health in the UK & COVID-19: A cohort study

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Abstract

Objectives: Previous pandemics have resulted in significant consequences for mental health. Here we report the mental health sequelae of the COVID-19 pandemic in a UK cohort and examine modifiable and non-modifiable explanatory factors associated with mental health outcomes. We focus on the first wave of data collection which examined short-term consequences for mental health, as reported during the first four-six weeks of social distancing measures being introduced.

Design: Cross sectional online survey

Setting: Community cohort study

Participants: N=3097 adults aged ≥ 18 years were recruited through a mainstream and social media campaign between 3/4/20-30/4/20. The cohort was predominantly female (n=2618); mean age forty-four years; 10% (n=296) from minority ethnic groups; 50% (n=1559) described themselves as key-workers and 20% (n=649) identified as having clinical risk factors putting them at increased risk of COVID-19

Main outcome measures: depression, anxiety and stress scores.

Results: Mean scores for depression ($\bar{x}=7.69$, $sd=6.0$), stress ($\bar{x}=6.48$, $sd=3.3$), and anxiety ($\bar{x}=6.48$, $sd=3.3$) significantly exceeded population norms (all $p<0.0001$). Analysis of non-modifiable factors hypothesised to be associated with mental health outcomes indicated that being younger, female and in a recognised COVID-19 risk group were associated with increased stress, anxiety and depression, with the final multivariable models accounting for 7-14% of variance. When adding modifiable factors, significant independent effects emerged for positive mood, perceived loneliness and worry about getting COVID-19 for all outcomes, with the final multivariable models accounting for 54-57% of total variance.

Conclusions: Increased psychological morbidity was evident in this UK sample and found to be more common in younger people, women and in individuals who identified as being in recognised COVID-19 risk groups. Public health and mental health interventions able to ameliorate perceptions of risk of COVID-19, worry about COVID-19 loneliness, and boost positive mood may be effective.

Article Summary

- To our knowledge, this paper provides the first empirical evidence from a large cohort on the mental health impact of the COVID-19 pandemic on people in the UK
- The findings are based on a large community cohort of N=3097 adults aged 18 years or older, capturing the views of people across the UK, including key-workers and individuals from ethnic minority groups.
- The use of validated measures of mental health allows us to conclude that levels of depression, anxiety and stress significantly exceed previously reported population norms.
- The assessment of demographic and modifiable psychological variables allows us to report on which groups appear to be at greatest risk of increased psychological morbidity, and identifies a role for psychological and public health interventions.
- The cross-sectional design prohibits an analysis of causal relationships and the recruitment of a self-selected community sample has implications for generalisability.

Introduction

The COVID-19 (Coronavirus, 2019) pandemic has resulted in unprecedented disruption to the fabric of society, our health service and economy. However, the multitude of challenges presented by the pandemic may also pose a significant threat to our psychological health.¹ Individuals are facing a panoply of stressors including serious illness, bereavement, social distancing, and unemployment. The consequences of these stressors for mental health will not be uniform, rather they will be influenced by a range of modifiable and non-modifiable factors. Identification of the latter will be critical in determining who may be at greatest risk of mental health difficulties and should be the focus of future interventions; while the former can inform approaches to intervention. We report here cross-sectional findings from a community cohort study designed to capture both the mental health sequelae of the COVID-19 pandemic, as well as the modifiable and non-modifiable explanatory factors associated with adverse mental health outcomes. Our focus is on the immediate consequences for mental health, as reported during the first 4-6 weeks of social distancing measures being introduced in the UK.

In keeping with its recent emergence, much remains unknown about COVID-19 and its consequences. However, the expectation is that the consequences for both mental and physical health will be profound and far reaching.² With regard to the former, evidence from China attests to this possibility.^{3,4}, as does the experience of previous pandemics.^{5,6} Indeed, preliminary evidence from the UK suggests that these experiences may be replicated here.⁷ } But who might be at greatest risk of mental health difficulties? Individuals at increased risk of the disease and/or adverse outcomes might be expected to experience greater psychological morbidity. For example, the death rate is known to be higher in men and older individuals.^{8,9} The latter being also more likely to have co-existing conditions and be socially-isolated through shielding. The ethnic diversity of countries such as the US and UK has also highlighted that individuals from Black, Asian and Minority Ethnic (BAME) backgrounds appear to be affected disproportionately by the disease.¹⁰ Recent UK data also suggest that key-workers, in particular those in social care, are at greater risk of COVID-19 related mortality.⁸

The aforementioned factors are, however, largely non-modifiable and thus are valuable in understanding who may be at greatest risk of mental health difficulties and in need of intervention. Do modifiable risk factors exist which could be targets for intervention? Stress and coping theory.¹¹ attests that emotional responses to challenging situations vary according to both our appraisal of stressors and the availability of psychological and social resources. Cognitions are central to the former and evidence from previous pandemics and the COVID-19 pandemic suggest that perceptions of the risk of contracting the disease and increased worry about risks to health are positively associated with adverse mental health outcomes.¹²⁻¹⁴ In terms of resources, social support,

and its corollary loneliness, are among the best established determinants of our emotional responses to stressors. Successive systematic reviews demonstrate poorer mental health outcomes and increased morbidity and mortality in individuals who perceive themselves to be more lonely and lacking in support.^{15,16} Positive mood, now no longer viewed as just the opposite of negative mood, may also confer direct effects on well-being as well as protective effects in challenging situations.^{11,17-19} In terms of mental health, evidence suggests that the existence of positive mood reduces the risk of mood disorders by 28% and anxiety disorders by 53%, and also influences recovery from some mental health conditions.^{20,21}

Taken together there is an urgent need to report evidence on the prevalence of mental health problems during the COVID-19 pandemic, to understand who may be at greatest risk, and to explore the psychological and social resources that may mitigate this risk. To that end, we report cross sectional findings from a community cohort established in April 2020 to prospectively examine the mental health consequences of the pandemic. We focus here on findings from the first survey conducted between 3rd and 30th April 2020 which coincided with the first 4-6 weeks of social distancing measures being introduced in the UK.

Methods

Ethics, Recruitment and Eligibility

Ethical approval was granted from the University of Nottingham Faculty of Medicine and Health Sciences (ref: 506-2003) and the NHS Health Research Authority (ref: 20/HRA/1858). The study was launched on 3/4/20 with participants recruited in the community through a social and mainstream media campaign involving, but not limited to, Facebook and Twitter. In addition, HRA regulatory approval enabled us to approach NHS organisations and request they advertise the research through their routine communications. Recruitment continued until 30/4/20. All media directed potential participants to the study website (www.covidstresstudy.co.uk) through which they accessed the information sheet, consent form and online survey.

Eligibility criteria specified that participants should be: aged 18 and over; able to give informed consent; able to read English; residing in the UK at the time of completing the survey and able to provide a sample of hair at least 1 cm long. The latter was collected for the determination of the stress biomarker cortisol which will be the subject of future manuscripts.

Patient and public involvement (PPI)

We convened a virtual PPI group to support this research the aims of which were to advise on the development of the survey, the participant information sheet and optimising recruitment and retention. Individuals participated via MS Teams in one-to-one or group discussions. These discussions informed the length and structure of the survey, language of the information sheet and strategies for recruiting via media and social media. The views of this group were instrumental in achieving our large sample size. This group also advised on providing regular feedback to participants on study findings through the study website and between each wave of data collection.

Sample size

We did not place an upper limit on participant numbers to enable us to obtain precise estimates of population values and associations, and to be able to examine these in subgroups. As a minimum we estimated that 252 participants would be required to detect an R^2 value of 0.1, with 90% power and a 5% significance level based on inclusion of 20 explanatory variables in a multiple linear regression model.

Procedures

Consenting participants completed an online survey implemented through JISC Online Survey (<https://www.onlinesurveys.ac.uk/>). In the first wave of data collection reported here, the survey included validated measures capturing the mental health outcomes: anxiety ($\alpha=0.88$), depression ($\alpha=0.92$) and stress ($\alpha=0.76$).²²⁻²⁵ Depression was measured using the 9-item Patient Health Questionnaire (PHQ-9) where participants were asked how often, over the past 2 weeks, they were bothered by each problem and selected their answers from a 4-point scale ranging from “not at all” (0) to “nearly every day” (3). PHQ-9 scores range from 0 to 27 with higher scores indicating worse levels of depression severity. Anxiety was measured using the 7-item Generalized Anxiety Disorder Scale (GAD-7) where participants were asked how often, during the last 2 weeks, they have been bothered by each problem and selected their responses from a 4-point list: “not at all” – “nearly every day” (0-3). GAD-7 scores range from 0 to 21 with higher scores indicating worse anxiety levels. Stress was measured using the 4-item Perceived Stress Scale (PSS-4) where participants were asked to rate how often they have experienced stress over the last two weeks on a 5-point scale ranging from “Never” (0) to “Very often” (4). Total scores of PSS-4 range from 0 to 16 with higher scores indicating higher levels of stress. We also measured modifiable and non-modifiable variables we hypothesised would be related to these mental health outcomes due to being (i) associated with an increased risk of contracting COVID-19 and/or adverse disease outcomes; or (ii) known to be directly associated with adverse mental health outcomes. These were: age,

gender, ethnicity, key-worker status, living alone, positive mood, worry about contracting COVID-19 and perceived loneliness and risk of COVID-19 (see supplementary appendix 1). Positive mood was measured using six items from the Scale of Positive and Negative Experience (SPANE).²⁵ Total scores of positive mood range from 6 to 30 with higher scores indicating greater positive mood. COVID-19 risk status, perceived risk of contracting COVID-19, COVID-19 worry, perceived loneliness, and living alone were all measured using single items which are described in supplementary appendix 1.

Statistical analysis

We first summarised the outcome variables (depression, anxiety and stress scores) and participant characteristics with appropriate summary statistics and examined histograms and scatterplots. Comparisons with pre-pandemic normative values were made using independent samples t-tests. Examination of histograms indicated both depression and anxiety scores deviated from a normal distribution, however transformations or non-parametric tests were not suitable for these comparisons as only summary statistics not individual level data were available for normative data. While t-tests are robust to deviations from normality especially when sample sizes are large²⁶, results of these specific tests should be interpreted with appropriate caution. To explore the associations between the outcome variables and non-modifiable and modifiable explanatory factors we first conducted univariable linear regression analyses (see supplementary appendix 2). Multivariable linear regression analyses were then used to explore the independent relationships of non-modifiable factors (age, gender, ethnicity, keyworker status, living alone, being in a recognised COVID-19 risk group) on outcome variables. Then, in subsequent models, modifiable explanatory factors (perceived loneliness, perceived risk of COVID-19, positive mood, worry about contracting COVID-19) were added to examine the additional and independent contribution of these factors to explaining variation in the outcome variables. The variable assessing COVID-19 worry was treated as a categorical variable in all models, with “occasional worry” treated as the reference value as this was the most common response. Assumptions of linear regression (normality and homoscedasticity of residuals, linearity with continuous variables) and presence of outliers were assessed graphically. Multicollinearity was checked for all models using variance inflation factors (VIF) and found to have acceptable levels. Square root transformations were used for depression and anxiety scores to satisfy assumptions. Robustness of the models was examined by removing data points with large residuals (<-3 or >3) and comparing results to the original models. In the vast majority of models, this had no substantive effect on interpretation. Thus these results are

only mentioned where interpretation may be affected. Additionally, as perceived risk of getting COVID-19 was not assessed in those who thought they had had it (n=519) these participants are not represented in final multivariable models. As a sensitivity analysis, models were additionally re-specified excluding this explanatory variable (see supplementary appendix 3).

For depression and anxiety we also carried out additional analyses dichotomising according to established cut-offs (scores of 10 or greater indicating moderate or severe levels)^{22,23}. We used multiple logistic regression to estimate odds ratios with 95% confidence intervals for their associations with non-modifiable and modifiable variables.

Statistical analyses were performed using STATA (version 16).

Role of sponsor

The study sponsor did not play a role in the study design, collection; analysis, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Results

Cohort characteristics

The final number of participants recruited was n=3102. Of these, five were ineligible due to being less than 18 years old. Thus, yielding n=3097 eligible participants. The largest proportion of visitors to the website came direct to the URL (62%/n=15,218), followed by 25% (n=6068) via Facebook (the remainder through other websites). The vast majority of respondents accessed the website via a mobile phone (70%/n=17045). The survey was completed in full by 100% of those who started it, consequently there were no missing data, with the exception of age, for which 2 participants entered non-numeric values.

Table 1 summarises the main characteristics of the participants, alongside comparative data on UK population values where available. This shows that females were proportionally over-represented and participants older than 75 years, and from Northern Ireland, were under-represented in the current cohort. Otherwise the sample was reasonably representative of the wider UK population. The cohort had a mean age of 44 years (standard deviation=15); and 10% (n=296) from minority ethnic backgrounds. Fifty percent (n=1559) described themselves as key-workers (39%/n=1198 identifying as working in health and social care). Twenty percent (n=649) identified themselves as having clinical risk factors which would put them at increased or greatest risk of COVID-19.

Table 1: Participant Demographics (n=3097) and UK population values

	Participants	UK population
	n (%)	n (%)
Gender ^a		
Male	476 (15.4%)	32,978,229 (49.4%)
Female	2618 (84.5%)	33,818,578 (50.6%)
Prefer not to say	3 (0.1%)	NR
Age groups (years) ^a		
		52,673,433
18-24	364 (11.8%)	5,647,655 (10.7%)
25-34	528 (17.1%)	9,011,381 (17.1%)
35-44	637 (20.6%)	8,415,206 (16.0%)
45-54	690 (22.3%)	9,063,137 (17.2%)
55-64	570 (18.4%)	8,161,093 (15.4%)
65-74	257 (8.3%)	6,687,066 (12.7%)
≥75	49 (1.6%)	5,687,895 (10.8%)
Ethnicity ^b		
White – British, Irish, other	2796 (90.3%)	48,209,395 (86.0%)
Asian/Asian British – Indian, Pakistani, Bangladeshi, other	119 (3.8%)	3,820,390 (6.8%)
Black/Black British – Caribbean, African, other	42 (1.4%)	1,864,890 (3.3%)
Chinese/Chinese British	28 (0.9%)	393,141 (0.7%)
Mixed race – White and Black/Black British	19 (0.6%)	934,416 (1.7%)
Middle Eastern/Middle Eastern British – Arab, Turkish, other	23 (0.7%)	NR
Mixed race – other	40 (1.3%)	289,984 (0.5%)
Other ethnic group	25 (0.8%)	563,696 (1.0%)
Prefer not to say	5 (0.2%)	NR
Relationship status		
Single, never married	574 (18.5%)	NR
Single, divorced or widowed	263 (8.5%)	NR
In a relationship/married but living apart	254 (8.2%)	NR
In a relationship/married and cohabiting	1981 (64.0%)	NR
Prefer not to say	25 (0.8%)	NR
Education (highest level of attainment)		
No qualifications	33 (1.1%)	NR
Completed GSCE/CSE/O-levels or equivalent	252 (8.1%)	NR
Completed post-16 vocational course	101 (3.3%)	NR
A-levels or equivalent (at school until aged 18)	403 (13.0%)	NR
Undergraduate degree or professional qualification	1306 (42.2%)	NR
Postgraduate degree	976 (31.5%)	NR
Prefer not to say	26 (0.8%)	NR
Place of residence ^a		
South West England	241 (7.8%)	5,624,696 (8.4%)
East Midlands	762 (24.6%)	4,835,928 (7.2%)

Yorkshire and Humber	293 (9.5%)	5,502,967 (8.2%)
North East	147 (4.8%)	2,669,941 (4.0%)
East of England	153 (4.9%)	6,236,072 (9.3%)
North West	357 (11.5%)	7,341,196 (11.0%)
South East England	415 (13.4%)	9,180,135 (13.7%)
Greater London	329 (10.6%)	8,961,989 (13.4%)
West Midlands	165 (5.3%)	5,934,037 (8.9%)
Northern Ireland	8 (0.3%)	1,893,667 (2.8%)
Wales	73 (2.4%)	3,152,879 (4.7%)
Scotland	154 (5.0%)	5,463,300 (8.2%)
Key-worker status		
Health, social care or relevant related support worker	1198 (38.7%)	NR
Teacher or childcare worker still travelling in to work	70 (2.3%)	NR
Transport worker still travelling in to work	1 (0.03%)	NR
Food chain worker (e.g. production, sale, delivery)	33 (1.1%)	NR
Key public services worker (e.g. justice staff, religious staff, public service journalist or mortuary worker)	22 (0.7%)	NR
Local or national government worker delivering essential public services	41 (1.3%)	NR
Utility worker (e.g. energy, sewerage, postal service)	5 (0.2%)	NR
Public safety or national security worker	11 (0.4%)	NR
Worker involved in medicines or protective equipment production or distribution	10 (0.3%)	NR
Other key worker role not listed	168 (5.4%)	NR
Not a key worker	1538 (49.7%)	NR
Living alone (or with others)		
Living alone	406 (13.1%)	NR
Living with others	2691 (86.9%)	NR
COVID-19 risk groups		
Most at risk (e.g. suffering from advanced cancer, severe asthma/COPD, etc.)	121 (3.9%)	NR
At increased risk (e.g., being pregnant, aged over 70, etc.)	528 (17.1%)	NR
Not at-risk	2448 (79.0%)	NR

^a UK population estimates from Office for National Statistics, mid-year estimates 2019.

^b UK population estimates from 2011 census data.

NR not reported or not available

Mental health status

Table 2 summarises findings in relation to levels of stress, anxiety and depression in the cohort. The mean values for all measures indicate levels that are higher in women than men and decrease with age. Overall mean values are significantly higher than previously reported population norms²⁷⁻²⁹. For both anxiety and depression the means for the cohort were higher for both genders compared with their respective population norms, and also for all age ranges between 25-64 years. In contrast, both men and women aged over 65 years had anxiety and depression scores consistent with previous population norms. The data suggested no significant differences in stress scores by gender, despite the combined mean score exceeding the population norm. Means scores for

depression, anxiety, and stress weighted to reflect the most recent UK age and gender distributions (Office for National Statistics, mid-year estimates 2019) are presented in supplementary appendix 4 and show similarly elevated levels in both men and women compared to pre-pandemic population norms.

Table 3 shows the categorisation of participants in line with established cut-offs for anxiety and depression. This shows 64% of participants reported symptoms of depression and 57% reported symptoms of anxiety. When considering the thresholds at which someone would qualify for high intensity psychological support (score of 10 or greater) in the NHS,²⁶ we observe that 31.6% reported moderate to severe depression and 26% moderate to severe anxiety.

Table 2: Depression (PHQ-9), anxiety (GAD-7) and stress (PSS-4) scores and published population normative data†

	PHQ-9 score			GAD-7 score			PSS-4 score		
	Participants	Norms	t	Participants	Norms	t	Participants	Norms	t
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Total Score	7.69 (6.0)	2.91 (3.5)	45.31****	6.59 (5.6)	2.95 (3.4)	36.52****	6.48 (3.3)	6.11 (3.1)	3.80****
Gender									
Male	6.49 (6.1)	2.7 (3.5)	18.56****	5.22 (5.4)	2.66 (3.2)	13.77****	5.88 (3.3)	5.56 (3.0)	1.57 (<i>p</i> =0.12)
Female	7.91 (6.0)	3.1 (3.5)	35.80****	6.84 (5.5)	3.20 (3.5)	28.83****	6.59 (3.3)	6.38 (3.2)	1.73 (<i>p</i> =0.084)
Age groups (years)									
18-24	11.24 (6.4)	..	..	9.02 (6.0)	..	..	8.13 (3.3)	..	..
25-34	8.74 (5.9)	2.3 (3.2)	23.56****	7.73 (5.6)	2.81 (3.3)	13.85****	6.94 (3.3)	..	..
35-44	8.23 (6.0)	2.6 (3.5)	23.45****	7.25 (5.7)	2.82 (3.3)	14.09****	6.467 (3.2)	..	..
45-54	7.32 (5.7)	2.8 (3.5)	19.24****	6.28 (5.3)	3.14 (3.4)	10.71****	6.16 (3.0)	..	..
55-64	6.35 (5.6)	3.2 (3.5)	13.03****	5.43 (5.1)	3.25 (3.6)	7.36****	5.94 (3.2)	..	..
65-74	3.83 (4.3)	3.3 (3.6)	1.95 (<i>p</i> =0.051)	3.32 (3.8)	2.79 (3.2)	1.92 (<i>p</i> =0.056)	5.07 (3.0)	..	..
≥75	4.39 (5.8)	4.4 (3.9)	0.02 (<i>p</i> =0.99)	2.92 (4.4)	3.05 (3.4)	0.21 (<i>p</i> =0.83)	4.80 (3.0)	..	..

† PHQ-9, the 9-item Patient Health Questionnaire;²² GAD-7, the 7-item Generalized Anxiety Disorder Scale;²³ PSS-4, the 4-item Perceived Stress Scale.²⁴ Published population normative data for PHQ-9²⁷, GAD-7²⁹, PSS-4²⁸.

**** *p*<0.0001, *** *p*<0.001, ** *p*<0.01, * *p*<0.05

Table 3: Prevalence of depressive and anxiety cases[†]

Categories	Whole sample		Male		Female		
	n	%	n	%	n	%	
Depression (PHQ-9[‡])	<i>No-Minimal Depression (0-4)</i>	1125	36.3	230	48.3	894	34.1
	<i>Mild Depression (5-9)</i>	994	32.1	125	26.3	868	33.2
	<i>Moderate Depression (10-14)</i>	525	17.0	64	13.4	461	17.6
	<i>Moderately Severe Depression (15-19)</i>	276	8.9	35	7.4	241	9.2
	<i>Severe Depression (20-27)</i>	177	5.7	22	4.6	154	5.9
Anxiety (GAD-7[‡])	<i>No-Minimal Anxiety (0-4)</i>	1344	43.4	276	58.0	1066	40.7
	<i>Mild Anxiety (5-9)</i>	947	30.6	108	22.7	839	32.0
	<i>Moderate Anxiety (10-14)</i>	430	13.9	44	9.2	386	14.7
	<i>Severe Anxiety (15-21)</i>	376	12.1	48	10.1	327	12.5

[†] Cut-offs for categories in line with published guidelines for PHQ-9²³ and GAD-7.²⁵

[‡] PHQ-9, the 9-item Patient Health Questionnaire;¹⁹ GAD-7, the 7-item Generalized Anxiety Disorder Scale.²⁰

Individuals at greatest risk of mental health problems: associations with age, gender, ethnicity, living alone and key-worker status

When non-modifiable explanatory variables were included in a multivariable model (Table 4), we observed that for depression (square-root transformed scores), being younger ($B=-0.30$, 95% CI: -0.33, -0.27 per decade), female ($B=0.36$, 95% CI: 0.25, 0.47), living alone ($B=0.34$, 95% CI: 0.25, 0.47) and being in a recognised risk group for COVID-19 (“most at risk” group: $B=0.56$, 95% CI: 0.35, 0.77; “increased risk” group: $B=0.27$, 95% CI: 0.16, 0.38) were all independently significantly associated with greater levels of depression. This model accounted for 14% of the variance in depression scores. These results were replicated when considering depression as a binary outcome (i.e., cases requiring high intensity intervention versus not) with those in recognised risk groups for COVID-19 being more likely to have a depression score above 10 with 98% increased odds in the “most at risk” group and 63% increased odds in those in the “increased risk” group compared to those in neither risk group. In addition, females had a 50% increased odds of having depression scores above 10 and living alone was associated with a 53% increase.

Table 4: Regression models showing associations between non-modifiable explanatory variables and depression scores

	Regression coefficient (B)	95% CI Lower	95% CI Upper	β	p
PHQ-9 Total Score^a					
Age (per decade)	-0.30	-0.33	-0.27	-0.36	<.0001****
Female	0.36	0.25	0.47	0.11	<.0001****
Live alone	0.33	0.21	0.45	0.09	<.0001****
BAME background	0.03	-0.11	0.17	0.01	0.70
Key-worker	0.08	-0.00	0.16	0.03	0.07
Risk Group ^b					
Most at risk	0.56	0.35	0.77	0.09	<.0001****
Increased risk	0.27	0.16	0.38	0.08	<.0001****
Adjusted R²=0.14, n=3090					
	Odds Ratio	95% CI Lower	95% CI Upper	β	p
PHQ-9 “Cases”^c					
Age (per decade)	0.65	0.61	0.69	-1.38	<.0001****
Female	1.50	1.19	1.89	0.31	<.001***
Live alone	1.53	1.21	1.93	0.31	<.001***
BAME background	1.14	0.88	1.48	0.08	0.31
Key-worker	1.16	0.99	1.36	0.16	0.06
Risk Group ^b					
Most at Risk	1.98	1.33	2.94	0.28	<.001***
Increased Risk	1.63	1.31	2.02	0.39	<.0001****
Pseudo R²=0.07, n=3090					

**** $p<0.0001$, *** $p<0.001$, ** $p<0.01$, * $p<0.05$

^a A square-root transformation was applied to the dependent variable.

^b Comparison reference group “I am in neither risk category”.

^c a “case” is defined as a PHQ-9 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS.

For anxiety (square-root transformed scores) being younger ($B=-0.26$, 95% CI: -0.29, -0.23 per decade), female ($B=0.43$, 95% CI: 0.32, 0.55), being a key-worker ($B=0.09$, 95% CI: 0.01, 0.18), and being in a recognised

COVID-19 risk group (“most at risk” group: B=0.42, 95% CI: 0.20, 0.63; “increased risk” group: B=0.21, 95% CI: 0.10, 0.33) were independently significantly associated with greater levels of anxiety (Table 5). This model accounted for 11% of the variance in anxiety scores and these results were replicated when considering anxiety as a binary outcome (i.e., cases requiring high intensity intervention versus not), with the exception that being a key-worker was no longer a statistically significant independent predictor.

Table 5: Regression models showing associations between non-modifiable explanatory variables and anxiety scores

	B	95% CI Lower	95% CI Upper	β	p
GAD-7 Total Score^a					
Age (per decade)	-0.26	-0.29	-0.23	-0.31	<.0001****
Female	0.43	0.32	0.55	0.13	<.0001****
Live alone	-0.04	-0.16	0.08	-0.01	0.51
BAME background	0.02	-0.12	0.16	0.00	0.81
Key-worker	0.09	0.01	0.18	0.04	0.03*
Risk Group ^b					
Most at Risk	0.42	0.20	0.63	0.07	<.001***
Increased Risk	0.21	0.10	0.33	0.07	<.001***
Adjusted R²=0.11, n=3090					
	Odds Ratio	95% CI Lower	95% CI Upper	β	p
GAD-7 “Cases”^c					
Age (per decade)	0.69	0.65	0.73	-1.28	<.0001****
Female	1.61	1.25	2.08	0.39	<.001***
Live alone	1.00	0.77	1.30	0.00	0.98
BAME background	1.15	0.88	1.50	0.09	0.32
Key-worker	1.14	0.97	1.35	0.15	0.12
Risk Group ^b					
Most at Risk	1.78	1.18	2.67	0.25	0.005**
Increased Risk	1.30	1.03	1.64	0.22	0.03*
Pseudo R²=0.05, n=3090					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a A square-root transformation was applied to the dependent variable.

^b Comparison reference group “I am in neither risk category”.

^c a “case” is defined as a GAD-7 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS.

For stress scores, being younger (B=-0.56, 95% CI: -0.64, -0.49 per decade), female (B=0.78, 95% CI: 0.46, 1.09), living alone (B=0.46, 95% CI: 0.12, 0.79), being from a BAME background (B=0.44, 95% CI: 0.05, 0.82), and being from an identified COVID-19 risk group (“most at risk” group: B=1.10, 95% CI: 0.51, 1.68; “increased risk” group: B=0.40, 95% CI: 0.09, 0.71) were all independently significantly associated with greater stress scores. In robustness analyses, when removing large standardised residuals (<-3 or >3) being a key-worker was also a statistically significant independent predictor (B=-0.22, 95% CI: -0.45, -0.002) such that being a key-worker was associated with lower stress scores). Together the model accounted for 7% of the variance in stress scores (Table 6).

Table 6: Regression model showing associations between non-modifiable explanatory variables and stress scores

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
PSS-4 Total Score					
Age (per decade)	-0.56	-0.64	-0.49	-0.26	<.0001****
Female	0.78	0.47	1.09	0.09	<.0001****
Live alone	0.46	0.12	0.79	0.05	0.008**
BAME background	0.44	0.05	0.82	0.04	0.03*
Key-worker	-0.22	-0.45	0.00	-0.03	0.06
Risk Group ^a					
Most at Risk	1.10	0.51	1.68	0.06	<.001***
Increased Risk	0.40	0.09	0.71	0.05	0.01*
Adjusted R²=0.07, n=3090					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I am in neither risk category”.

Individuals at greatest risk of mental health problems: associations with perceived risk of COVID-19, perceived loneliness, COVID-19 worry and positive mood

Table 7 shows scores for modifiable explanatory variables (perceived risk, perceived loneliness, COVID-19 worry, and positive mood) across the whole sample, as well as by gender and age-groups.

Table 7: Loneliness, worry about COVID-19, perceived risk of COVID-19, and positive mood

	Gender			Age groups (years)						
	Whole sample	Male	Female	18-24	25-34	35-44	45-54	55-64	65-74	≥75
Loneliness										
Mean (SD)	3.86 (2.7)	3.56 (2.7)	3.91 (2.7)	5.34 (2.7)	4.36 (2.7)	3.75 (2.7)	3.61 (2.8)	3.49 (2.7)	2.70 (2.1)	2.65 (2.4)
Positive mood										
Mean (SD)	18.99 (5.1)	19.76 (5.1)	18.85 (5.0)	17.68 (4.9)	18.82 (5.1)	18.68 (5.0)	18.93 (5.1)	19.35 (5.0)	20.71 (4.7)	22.59 (4.5)
Perceived risk of COVID-19										
Mean (SD)	4.75 (2.2)	4.46 (2.2)	4.80 (2.2)	4.10 (2.0)	4.92 (2.2)	5.14 (2.2)	5.01 (2.2)	4.78 (2.3)	4.20 (2.1)	3.00 (1.7)
Worry about COVID-19										
No worry (n, %)	512 (16.5%)	105 (22.1%)	406 (15.5%)	105 (28.9%)	108 (20.5%)	92 (14.4%)	92 (13.3%)	65 (11.4%)	39 (15.2%)	10 (20.4%)
Occasional worry (n, %)	2050 (66.2%)	318 (66.8%)	1731 (66.1%)	209 (57.4%)	320 (60.6%)	428 (67.2%)	468 (67.8%)	398 (69.8%)	191 (74.3%)	36 (73.5%)
Much worry (n, %)	413 (13.3%)	40 (8.4%)	373 (14.3%)	39 (10.7%)	77 (14.6%)	91 (14.3%)	94 (13.7%)	85 (14.9%)	24 (9.3%)	2 (4.1%)
Most worry (n, %)	122 (3.9%)	13 (2.7%)	108 (4.1%)	11 (3.0%)	23 (4.4%)	26 (4.1%)	36 (5.2%)	22 (3.9%)	3 (1.2%)	1 (2.0%)

When modifiable explanatory variables were added into the multivariable model for depression: this revealed that greater perceived loneliness (B=0.10, 95% CI: 0.09, 0.12), lower positive mood (B=-0.12, 95% CI: -0.12, -0.11) and greater than occasional worry about getting COVID-19 (much of time: B=0.26, 95% CI: 0.16, 0.36; most of time: B=0.30, 95% CI: 0.12, 0.48), were all independently and significantly associated with greater levels of depression, in addition to age, gender and being in a recognised COVID-19 risk group. The model accounted for 57% of the variance in depression scores. These results were largely replicated when considering depression as a binary outcome although gender and being in the “most at risk” group were no longer statistically significant (Table 8).

Table 8: Regression models showing associations between modifiable explanatory variables and depression scores

	B	95% CI Lower	95% CI Upper	β	p
PHQ-9 Total Score^a					
Age (per decade)	-0.19	-0.21	-0.17	-0.24	<.0001****
Female	0.19	0.10	0.28	0.06	<.0001****
Live alone	0.01	-0.09	0.11	0.00	0.79
BAME background	-0.02	-0.14	0.09	-0.01	0.67
Key-worker	0.02	-0.05	0.09	0.01	0.52
Risk Group ^b					
Most at Risk	0.26	0.09	0.43	0.04	0.002**
Increased Risk	0.20	0.11	0.29	0.06	<.0001****
Perceived loneliness (per unit)	0.10	0.09	0.12	0.22	<.0001****
Positive mood (per unit)	-0.12	-0.12	-0.11	-0.48	<.0001****
COVID-19 worry ^c					
No worry	0.00	-0.09	0.09	0.00	0.97
Much of time	0.26	0.16	0.36	0.07	<.0001****
Most of time	0.30	0.12	0.48	0.05	0.001**
Perceived risk of COVID-19 (per unit)	0.01	-0.00	0.03	0.02	0.13
Adjusted R²=0.57, n=2494					
	Odds Ratio	95% CI Lower	95% CI Upper	β	p
PHQ-9 “Cases”^d					
Age (per decade)	0.66	0.61	0.72	-1.38	<.0001****
Female	1.08	0.78	1.50	0.06	0.66
Live alone	0.88	0.61	1.25	-0.10	0.47
BAME background	0.96	0.65	1.40	-0.03	0.82
Key-worker	1.09	0.86	1.38	0.09	0.49
Risk Group ^b					
Most at Risk	1.28	0.74	2.21	0.11	0.37
Increased Risk	1.61	1.19	2.19	0.40	0.002**
Perceived loneliness (per unit)	1.22	1.16	1.28	1.19	<.0001****
Positive mood (per unit)	0.76	0.74	0.79	-3.01	<.0001****
COVID-19 worry ^c					
No worry	1.02	0.73	1.44	0.02	0.90
Much of time	1.67	1.23	2.28	0.38	0.001**
Most of time	2.02	1.13	3.62	0.29	0.02*
Perceived risk of COVID-19 (per unit)	1.04	0.98	1.10	0.18	0.20
Pseudo R²=0.36, n=2494					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a A square-root transformation was applied to the dependent variable.

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”.

^d a “case” is defined as a PHQ-9 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS.

For anxiety, the model revealed that greater perceived loneliness ($B=0.06$, 95% CI: 0.04, 0.07), lower positive mood ($B=-0.12$, 95% CI: -0.13, -0.11) and greater perceived risk of COVID-19 ($B=0.04$, 95% CI: 0.02, 0.05) were all independently and significantly associated with greater anxiety, in addition to the non-modifiable factors of being younger, female and living alone. Further, those participants who experienced greater than occasional worry about getting COVID-19 were significantly more likely to have higher levels of anxiety (much of time: $B=0.57$, 95% CI: 0.47, 0.68; most of time: $B=0.87$, 95% CI: 0.68, 1.06); with those who did not worry at all about getting COVID-19 being likely to have lower anxiety ($B=-0.18$, 95% CI: -0.28, -0.09). The model accounted for 54% of the variance in anxiety scores. These results were largely replicated when considering anxiety as a binary outcome, although gender and not worrying at all about getting COVID-19 were no longer statistically significant (Table 9).

Table 9: Regression models showing associations between modifiable explanatory variables and anxiety

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
GAD-7 Total Score^a					
Age (per decade)	-0.16	-0.18	-0.14	-0.20	<.0001****
Female	0.25	0.16	0.34	0.07	<.0001****
Live alone	-0.25	-0.36	-0.15	-0.07	<.0001****
BAME background	-0.08	-0.19	0.04	-0.02	0.19
Key-worker	-0.03	-0.11	0.04	-0.01	0.34
Risk Group ^b					
Most at Risk	0.02	-0.15	0.19	0.00	0.83
Increased Risk	0.07	-0.02	0.16	0.02	0.13
Perceived loneliness (per unit)	0.06	0.04	0.07	0.12	<.0001****
Positive mood (per unit)	-0.12	-0.13	-0.11	-0.48	<.0001****
COVID-19 worry ^c					
No worry	-0.18	-0.28	-0.09	-0.05	<.001***
Much of time	0.57	0.47	0.68	0.15	<.0001****
Most of time	0.87	0.68	1.06	0.13	<.0001****
Perceived risk of COVID-19 (per unit)	0.04	0.02	0.05	0.06	<.0001****
Adjusted R²=.54, n=2494					
	Odds Ratio	95% CI Lower	95% CI Upper	β	<i>p</i>
GAD-7 “Cases”^d					
Age (per decade)	0.69	0.63	0.76	-1.32	<.0001****
Female	1.17	0.82	1.67	0.13	0.38
Live alone	0.67	0.46	0.99	-0.31	0.04*
BAME background	0.96	0.65	1.44	-0.03	0.86
Key-worker	0.89	0.70	1.15	-0.13	0.38
Risk Group ^b					
Most at Risk	0.89	0.51	1.55	-0.05	0.67
Increased Risk	0.92	0.66	1.29	-0.07	0.64
Perceived loneliness (per unit)	1.11	1.06	1.17	0.68	<.0001****
Positive mood (per unit)	0.77	0.75	0.80	-3.08	<.0001****
COVID-19 worry ^c					
No worry	0.75	0.52	1.09	-0.24	0.13
Much of time	3.90	2.88	5.29	1.07	<.0001****
Most of time	11.63	5.91	22.90	1.06	<.0001****
Perceived risk of COVID-19 (per unit)	1.07	1.01	1.14	0.35	0.02*
Pseudo R²=0.36, n=2494					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a A square-root transformation was applied to the dependent variable.

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”.

^d a “case” is defined as a GAD-7 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS.

The multivariable model for stress scores showed that greater perceived loneliness (B=0.19, 95% CI: 0.15, 0.23), lower positive mood (B=-0.38, 95% CI: -0.40, -0.36), greater than occasional worry about getting COVID-19 (much of time: B=0.37, 95% CI: 0.10, 0.63; most of time: B=1.02, 95% CI: 0.54, 1.50), and greater perceived risk of getting COVID-19 (B=0.06, 95% CI: 0.02, 0.11) were all independently and significantly associated with greater stress, in addition to being younger, female, living alone and not being a key-worker. In robustness analyses, when removing large standardised residuals (<-3 or >3) having a BAME background was also a statistically significant independent predictor (B=0.29, 95% CI: 0.00, 0.58). This model accounted for 57% of the variance in stress scores (Table 10).

Table 10: Regression model showing associations between modifiable explanatory variables and stress scores

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
PSS-4 Total Score					
Age (per decade)	-0.25	-0.31	-0.18	-0.12	<.0001****
Female	0.35	0.12	0.59	0.04	0.003**
Live alone	-0.41	-0.67	-0.14	-0.04	0.002**
BAME background	0.26	-0.04	0.55	0.02	0.09
Key-worker	-0.39	-0.58	-0.21	-0.06	<.0001****
Risk Group ^b					
Most at Risk	0.03	-0.41	0.47	0.00	0.90
Increased Risk	0.02	-0.21	0.26	0.00	0.83
Perceived loneliness (per unit)	0.19	0.15	0.23	0.15	<.0001****
Positive mood (per unit)	-0.38	-0.40	-0.36	-0.60	<.0001****
COVID-19 worry ^a					
No worry	-0.05	-0.30	0.19	-0.01	0.68
Much of time	0.37	0.10	0.63	0.04	0.007**
Most of time	1.02	0.54	1.50	0.06	<.0001****
Perceived risk of COVID-19 (per unit)	0.06	0.02	0.11	0.04	0.004**
Adjusted R²=.57, n=2494					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I occasionally worry about getting COVID-19”.

^b Comparison reference group “I am in neither risk category”.

Discussion

We report findings from the first wave of data collection from a community cohort study established in the UK to prospectively examine the mental health consequences of the COVID-19 pandemic. Our results pertain to the experiences of people within the first four to six weeks of social distancing measures being introduced, and focus on self-reported depression, anxiety and stress scores. The findings indicated that mean levels of depression, anxiety and stress significantly exceeded previously published population norms.²⁷⁻²⁹ Models examining the relationship between these mental health outcomes and non-modifiable explanatory factors accounted for only a modest proportion of the variance (7-14%). Increased depression was associated with being younger, female, living alone and being in a recognised COVID-19 risk group; increased anxiety was associated with being younger, female and being in a recognised risk group; and increased stress was associated with being younger, female, living alone, being from a BAME background and a recognised risk group. In contrast, when we added the hypothesised modifiable variables into our multivariable models we observed that the final models accounted for a much larger proportion of the variance (54-57%) with significant independent effects emerging for lower positive mood and greater perceived loneliness and worry about getting COVID-19 associated with higher scores for all three outcomes, as well as greater perceived risk of COVID-19 emerging as significant for anxiety and stress.

These findings highlight a number of issues worthy of discussion. First, we acknowledge several limitations.

These include the cross-sectional design which impedes an analysis of cause and effect. Thus, while we report

on several significant associations it remains the case that we can't be certain whether the relationships are causal, or simply due to the presence of other unmeasured characteristics; or indeed be certain of the direction of these relationships (i.e., reverse causality). For example, it is possible that lower positive mood leads to greater depression and that greater depression leads to lower positive mood.

A further limitation concerns the absence of information on pre-existing mental health conditions. This could have influenced the severity and prevalence of psychological morbidity reported in this study.¹ Furthermore, the self-selected community cohort design could have introduced sampling biases limiting the generalisability of our findings. For example, the spread of participants across the UK was limited and individuals with an interest in and experience of mental health difficulties may have been over-represented. . Furthermore, typical of previous online surveys concerned with mental health, women were over-represented in our sample.³⁰ Thus, while our comparisons with UK census and Office of National Statistics data (see Table 1) indicated that across many parameters our cohort were largely representative of the UK population; and our supplementary analysis (appendix 4) weighted by the age and gender distribution in the UK in 2019 confirmed the presence of increased stress, anxiety and depression compared with pre-pandemic norms, we acknowledge that these areas of sampling bias have implications for the generalisability of our findings. We also note that, typical of online surveys, we are unable to determine the extent to which our findings were affected by non-response bias. We took a number of steps to minimise this including ensuring brevity of the survey, designing it in conjunction with our virtual PPI group and conducting supplementary analyses weighted to reflect the most recent UK age and gender distributions. But this remains a potential source of bias in our findings. Finally, we also note that our comparisons with normative data were limited to the most recent data we were able to access. For stress and depression, comparisons were made with data reported in 2013, but for anxiety it was 2008. We acknowledge there may have been population shifts in mental health in the intervening years which may account, in part, for some of the increase in mental health difficulties reported here.

A second observation is that both mean scores and measures of case-ness suggest that the COVID-19 pandemic may have contributed to an increased prevalence of mental health difficulties in the UK. This is true for depression, generalised anxiety disorder and stress and is in keeping with observations from other countries.^{3,4} Indeed, the proportion of participants who would require intensive support for depression and anxiety in the NHS does not compare favourably with recent historical estimates of the prevalence of mental health problems in the UK. For example, the 2014 ONS report on adult psychiatric morbidity reported a prevalence of 17% for six different common mental disorders.³¹ The prevalence of depression alone in the context of this pandemic is

almost double this. However, what we can't determine from this work is whether the apparent increase in psychological morbidity is an expected, but short-term response to the pandemic. Or if this distress is sustained over time and likely to warrant intervention. Longitudinal follow-ups of this and other cohorts will provide valuable data in this regard. Furthermore, as noted above, we also cannot be certain how much of the increase in psychological morbidity is attributable to the pandemic or a more general trend towards increased mental health concerns that has been suggested by some in recent years.³²

Third, the non-modifiable explanatory variables significantly associated with increased levels for all three of our mental health outcomes were being younger, female and in a recognised COVID-19 risk group. The findings regarding gender and age are of course recognised risk factors for mental health³³ and are also consistent with unpublished data from another UK community cohort recruited during the COVID-19 pandemic with a similar gender profile to our own,³⁴ suggesting that these groups may be the most in need of intervention. They are also, in part, consistent with our hypothesis that the greatest psychological morbidity would be observed in individuals at greatest risk of COVID-19. But they also clearly illustrate that for some (e.g., younger participants), the experience of psychological morbidity may be unrelated to their actual risk of COVID-19. These results may reflect the fact that the pandemic has resulted in a panoply of challenges likely to affect mental health that go beyond the disease itself. It could be hypothesised, for example, that some of the more immediate consequences such as unemployment, financial concerns and increased domestic violence would disproportionately affect younger people and women and this may explain our findings.

A fourth, and related issue, is that although being younger, female and in a recognised COVID-19 risk group were consistently associated with poorer mental health, the relationship was modest, accounting for, at best, 14% of the variance. In contrast, the modifiable explanatory measures when added to the multivariable models accounted for 54-57% of the total variance, with greater perceived loneliness, worry about getting COVID-19 and lower positive mood strongly associated with all three outcomes. These findings are encouraging as they suggest that there is considerable potential to develop interventions to mitigate the mental health effects of the pandemic.³⁵ But they also signal a role for public health interventions. For example, a robust and effective contact tracing system with regional level data could do much to allay people's worries about contracting the infection and also increase social participation which, in turn, would benefit perceived loneliness. Clear and consistent public health messaging regarding the use of face masks to reduce infection risk could be another effective strategy. Viewed this way, these public health interventions could simultaneously reduce the risk of COVID-19 infection as well as help to manage some of the concomitant psychological distress. There is, of

course, still likely to be increased demand for mental health services in response to the pandemic. However, our data suggest that public health control measures commonly used in response to epidemics and pandemics may also have a role to play.

A final issue concerns the effects of the pandemic beyond mental health. It is well known that when negative mood states persist over time they result in the dysregulation of physiological systems involved in the regulation of the immune system.³⁶ Thus, there exists significant potential for the psychological harm inflicted by the pandemic to translate into physical harm. This could include an increased susceptibility to the virus, worse outcomes if infected, or indeed poorer responses to vaccinations in the future.³⁶ Studies providing longitudinal data on the prevalence of psychological morbidity and appropriate biomarkers (e.g., cortisol) will be required to determine whether the risks to physical health go beyond the hypothetical.

In conclusion, we are among the first to provide evidence from a large cohort on the mental health impact of the COVID-19 pandemic on people in the UK. We provide early evidence that women, young people and individuals in recognised COVID-19 risk groups may be at particular risk. However, the strongest associations were with psychological characteristics such as worry about contracting COVID-19 and perceived loneliness. These findings, we suggest, indicate that robust public health measures, such as effective contact tracing, which reduce the public's concerns regarding risk of infection, could do much to ameliorate mental health difficulties.

Contributor statements

Ru Jia: study design, coordination and management of recruitment, preparation, analysis and interpretation of data, preparation and review of final manuscript.

Kieran Ayling: study design, coordination and management of recruitment, preparation, analysis and interpretation of data preparation and review of final manuscript.

Trudie Chalder: study design, analysis and interpretation of data preparation and review of final manuscript.

Adam Massey: study design, coordination and management of recruitment, preparation, analysis and interpretation of data and review of final manuscript.

Elizabeth Broadbent: study design, interpretation of data and review of final manuscript

Carol Coupland: study design, analysis and interpretation of data, preparation and review of final manuscript

Kavita Vedhara: research lead and overall guarantor for the article contributing to study design, coordination and management of recruitment, preparation, analysis and interpretation of data and preparation of manuscript.

As corresponding author, KV had access to all the data in the study and had final responsibility for the decision to submit for publication.

PPI: We would like to acknowledge the valuable contributions of our PPI group in supporting the design of our recruitment strategy, contents of the survey and the communication of findings to study participants.

No competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Transparency declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Data sharing

Data will be deposited in the University of Nottingham data archive. Access to this dataset will be embargoed for a period of 12 months to permit planned analyses of the dataset. After that it may be shared with the consent of the Chief Investigator. Extra data is available by contacting kavita.vedhara@nottingham.ac.uk.

Dissemination statement

We plan to disseminate results to study participants

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Supplementary Appendices

Appendix 1: Results from univariable regressions

Appendix 2: Multivariable regression models, excluding perceived risk of COVID-19

Appendix 3: Details of characteristics and measures

Appendix 4: Means for depression, anxiety and stress with overall means weighted to mid-2019 UK population distribution

Appendix 1: Results from univariable regressions

1.1 Depression (PHQ-9)

Table S1: Univariable regression coefficients for non-modifiable factors as predictors of depression scores

PHQ-9 Total Score (Square-Root Transformed)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Age (per decade)	-0.27**** (0.01)					
Female		0.37**** (0.06)				
Live alone			0.14* (0.06)			
BAME background				0.23** (0.07)		
Key-worker					0.12** (0.04)	
Risk Group ^a Most at Risk						0.46**** (0.11)
Increased Risk						0.00 (0.02)
Constant	3.68**** (0.06)	2.18**** (0.06)	2.47**** (0.02)	2.47**** (0.02)	2.43**** (0.03)	2.47**** (0.02)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group "I am in neither risk category".

Table S2: Univariable regression coefficients for modifiable factors as predictors of depression scores

PHQ-9 Total Score (Square-Root Transformed)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Perceived loneliness	0.25**** (0.01)			
Positive mood		-0.16**** (0.00)		
COVID-19 worry ^a				
No worry			0.00 (0.06)	
Much of time			0.83**** (0.06)	
Most of time			1.33**** (0.11)	
Perceived risk of COVID-19				0.08**** (0.01)
Constant	1.55**** (0.03)	5.53**** (0.06)	2.33**** (0.03)	2.03**** (0.06)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I occasionally worry about getting COVID-19”

Table S3: Univariable logistic regression coefficients for non-modifiable factors as predictors of depression cases^a

PHQ-9 “Cases”	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]
Age (per decade)	0.68**** [0.65, 0.72]					
Female		1.43** [1.14, 1.78]				
Live alone			1.15 [0.92, 1.43]			
BAME background				1.49** [1.17, 1.91]		
Key-worker					1.16 [1.00, 1.35]	
Risk Group ^b						
Most at Risk						1.59 [1.10, 2.31]
Increased Risk						1.14 [0.93, 1.39]
Constant	2.37**** [1.86, 3.03]	0.34**** [0.28, 0.42]	0.45**** [0.42, 0.49]	0.44**** [0.41, 0.48]	0.43**** [0.38, 0.48]	0.44**** [0.41, 0.48]

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a a “case” is defined as a PHQ-9 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I am in neither risk category”.

Table S4: Univariable logistic regression coefficients for modifiable factors as predictors of depression cases ^a

PHQ-9 “Cases”	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]
Perceived loneliness	1.46**** [1.42, 1.51]			
Positive mood		0.72**** [0.70, 0.74]		
COVID-19 worry ^b				
No worry			1.04 [0.84, 1.29]	
Much of time			2.97**** [2.39, 3.69]	
Most of time			8.27**** [5.44, 12.58]	
Perceived risk of COVID-19				1.12**** [1.08, 1.16]
Constant	0.09**** [0.08, 0.11]	156.94**** [99.53, 247.47]	0.35**** [0.32, 0.39]	0.24**** [0.20, 0.30]

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a a “case” is defined as a PHQ-9 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I occasionally worry about getting COVID-19”

1.2 Anxiety (GAD-7)

Table S5: Univariable regression coefficients for non-modifiable factors as predictors of anxiety scores

GAD-7 Total Score (Square-Root Transformed)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Age (per decade)	-0.24**** (0.01)					
Female		0.45**** (0.06)				
Live alone			-0.21** (0.07)			
BAME background				0.17* (0.08)		
Key-worker					0.15*** (0.04)	
Risk Group ^a Most at Risk						0.30** (0.11)
Increased Risk						-0.04 (0.06)
Constant	3.34**** (0.07)	1.87**** (0.06)	2.28**** (0.02)	2.23**** (0.02)	2.17**** (0.03)	2.25**** (0.02)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I am in neither risk category”.

Table S6: Univariable regression coefficients for modifiable factors as predictors of anxiety scores

GAD-7 Total Score (Square-Root Transformed)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Perceived loneliness	0.21**** (0.01)			
Positive mood		-0.16**** (0.00)		
COVID-19 worry ^a No worry			-0.22**** (0.06)	
Much of time			1.06**** (0.06)	
Most of time			1.75**** (0.11)	
Perceived risk of COVID-19				0.12**** (0.01)
Constant	1.45**** (0.03)	5.20**** (0.07)	2.08**** (0.02)	1.62**** (0.06)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I occasionally worry about getting COVID-19”

Table S7: Univariable logistic regression coefficients for non-modifiable factors as predictors of anxiety cases ^a

GAD-7 “Cases”	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]
Age (per decade)	0.70**** [0.66, 0.75]					
Female		1.56*** [1.22, 1.99]				
Live alone			0.80 [0.62, 1.02]			
BAME background				1.44** [1.11, 1.86]		
Key-worker					1.16 [0.99, 1.36]	
Risk Group ^b						
Most at Risk						1.47 [0.997, 2.16]
Increased Risk						0.96 [0.77, 1.19]
Constant	1.58*** [1.23, 2.04]	0.24**** [0.19, 0.30]	0.36**** [0.33, 0.39]	0.34**** [0.31, 0.37]	0.33**** [0.29, 0.37]	0.35**** [0.32, 0.38]

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a a “case” is defined as a GAD-7 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I am in neither risk category”.

Table S8: Univariable logistic regression coefficients for modifiable factors as predictors of anxiety cases ^a

GAD-7 “Cases”	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]	Odds Ratio [95% CI]
Perceived loneliness	1.37**** [1.32, 1.41]			
Positive mood		0.74**** [0.72, 0.76]		
COVID-19 worry ^b				
No worry			0.93 [0.72, 1.19]	
Much of time			5.03**** [4.02, 6.28]	
Most of time			24.75**** [14.83, 41.31]	
Perceived risk of COVID-19				1.18**** [1.14, 1.23]
Constant	0.09**** [0.08, 0.11]	70.16**** [45.39, 108.44]	0.23**** [0.21, 0.26]	0.14**** [0.11, 0.18]

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a a “case” is defined as a GAD-7 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I occasionally worry about getting COVID-19”

1.3 Stress (PSS-4)

Table S9: Univariable regression coefficients for non-modifiable factors as predictors of stress scores

PSS-4 Total Score	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Age (per decade)	-0.52**** (0.04)					
Female		0.71**** (0.16)				
Live alone			0.13 (0.17)			
BAME background				0.84**** (0.20)		
Key-worker					-0.11 (0.12)	
Risk Group ^a						
Most at Risk						0.97*** (0.30)
Increased Risk						-0.09 (0.16)
Constant	8.84**** (0.18)	5.88**** (0.15)	6.46**** (0.06)	6.40**** (0.06)	6.53**** (0.08)	6.45**** (0.07)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group "I am in neither risk category".

Table S10: Univariable regression coefficients for modifiable factors as predictors of stress scores

PSS-4 Total Score	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
Perceived loneliness	0.62**** (0.02)			
Positive mood		-0.46**** (0.01)		
COVID-19 worry ^a				
No worry			-0.14 (0.15)	
Much of time			1.90**** (0.17)	
Most of time			3.78**** (0.29)	
Perceived risk of COVID-19				0.22**** (0.03)
Constant	4.09**** (0.09)	15.28**** (0.16)	6.10**** (0.07)	5.31**** (0.15)

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group "I occasionally worry about getting COVID-19"

Appendix 2: Multivariable regression models, excluding perceived risk of COVID-19

Table S11: Regression model showing associations between modifiable explanatory variables and depression scores (excluding perceived risk of COVID-19)

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
PHQ-9 Total Score^a					
Age (per decade)	-0.18	-0.20	-0.16	-0.22	<.0001****
Female	0.20	0.11	0.28	0.06	<.0001****
Live alone	-0.00	-0.10	0.09	-0.00	0.92
BAME background	-0.06	-0.16	0.04	-0.01	0.26
Key-worker	0.07	0.01	0.12	0.03	0.03*
Risk Group ^b					
Most at Risk	0.20	0.05	0.35	0.03	0.01**
Increased Risk	0.15	0.07	0.23	0.05	<.001***
Perceived loneliness	0.10	0.08	0.11	0.22	<.0001****
Positive mood	-0.12	-0.13	-0.11	-0.50	<.0001****
COVID-19 worry ^c					
No worry	0.03	-0.05	0.11	0.01	0.45
Much of time	0.26	0.18	0.35	0.07	<.0001****
Most of time	0.34	0.19	0.50	0.05	<.0001****
Adj R²=.56, <i>p</i><.0001****					

**** *p*<0.0001, *** *p*<0.001, ** *p*<0.01, * *p*<0.05

^a A square-root transformation was applied to the dependent variable

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”

Table S12: Logistic regression model showing associations between modifiable explanatory variables and depression cases (excluding perceived risk of COVID-19)

	Odds Ratio	95% CI Lower	95% CI Upper	β	<i>p</i>
PHQ-9 “Cases”^a					
Age (per decade)	0.68	0.63	0.73	-1.24	<.0001****
Female	1.20	0.90	1.60	0.14	0.21
Live alone	0.84	0.61	1.15	-0.13	0.28
BAME background	0.98	0.70	1.37	-0.01	0.90
Key-worker	1.22	1.00	1.48	0.21	0.05
Risk Group ^b					
Most at Risk	1.18	0.72	1.94	0.07	0.51
Increased Risk	1.44	1.10	1.89	0.30	0.007**
Perceived loneliness	1.21	1.16	1.26	1.12	<.0001****
Positive mood	0.76	0.74	0.78	-2.96	<.0001****
COVID-19 worry ^c					
No worry	0.93	0.70	1.24	-0.06	0.63
Much of time	1.58	1.21	2.07	0.34	<.001***
Most of time	2.65	1.58	4.43	0.40	<.001***
Pseudo R²=0.34, n=3090					

**** *p*<0.0001, *** *p*<0.001, ** *p*<0.01, * *p*<0.05

^a a “case” is defined as a PHQ-9 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”

Table S13: Regression model showing associations between modifiable explanatory variables and anxiety scores (excluding perceived risk of COVID-19)

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
GAD-7 Total Score^a					
Age (per decade)	-0.16	-0.19	-0.14	-0.20	<.0001****
Female	0.25	0.16	0.33	0.07	<.0001****
Live alone	-0.27	-0.36	-0.17	-0.07	<.0001****
BAME background	-0.08	-0.18	0.03	-0.02	0.14
Key-worker	0.04	-0.02	0.10	0.02	0.17
Risk Group ^b					
Most at Risk	0.01	-0.15	0.17	0.00	0.92
Increased Risk	0.06	-0.02	0.15	0.02	0.13
Perceived loneliness	0.06	0.05	0.07	0.13	<.0001****
Positive mood	-0.12	-0.12	-0.11	-0.48	<.0001****
COVID-19 worry ^c					
No worry	-0.19	-0.27	-0.11	-0.06	<.0001****
Much of time	0.57	0.48	0.66	0.16	<.0001****
Most of time	0.87	0.71	1.03	0.14	<.0001****
Adj R²=0.53, n=3090					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a A square-root transformation was applied to the dependent variable

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”

Table S14: Logistic regression model showing associations between modifiable explanatory variables and anxiety cases (excluding perceived risk of COVID-19)

	Odds Ratio	95% CI Lower	95% CI Upper	β	<i>p</i>
GAD-7 “Cases”^a					
Age (per decade)	0.69	0.64	0.75	-1.25	<.0001****
Female	1.23	0.91	1.67	0.17	0.18
Live alone	0.56	0.40	0.79	-0.44	<.001***
BAME background	0.91	0.65	1.29	-0.06	0.61
Key-worker	1.11	0.90	1.36	0.11	0.34
Risk Group ^b					
Most at Risk	0.88	0.53	1.47	-0.05	0.63
Increased Risk	0.93	0.70	1.25	-0.06	0.65
Perceived loneliness	1.13	1.08	1.18	0.76	<.0001****
Positive mood	0.78	0.75	0.80	-2.91	<.0001****
COVID-19 worry ^c					
No worry	0.72	0.53	0.98	-0.28	0.04*
Much of time	3.59	2.76	4.68	0.99	<.0001****
Most of time	12.54	6.97	22.56	1.11	<.0001****
Pseudo R²=0.34, n=3090					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a a “case” is defined as a GAD-7 score greater than or equal to 10, at which level someone would qualify for high intensity psychological support in the NHS

^b Comparison reference group “I am in neither risk category”.

^c Comparison reference group “I occasionally worry about getting COVID-19”

Table S15: Regression model showing associations between modifiable explanatory variables and stress scores (excluding perceived risk of COVID-19)

	B	95% CI Lower	95% CI Upper	β	<i>p</i>
PSS-4 Total Score					
Age (per decade)	-0.25	-0.30	-0.19	-0.11	<.0001****
Female	0.31	0.09	0.52	0.03	0.005**
Live alone	-0.37	-0.61	-0.13	-0.04	0.003**
BAME background	0.21	-0.06	0.47	0.02	0.13
Key-worker	-0.24	-0.40	-0.09	-0.04	0.002**
Risk Group ^a					
Most at Risk	0.14	-0.27	0.54	0.01	0.50
Increased Risk	0.08	-0.13	0.30	0.01	0.43
Perceived loneliness	0.20	0.17	0.24	0.17	<.0001****
Positive mood	-0.38	-0.40	-0.36	-0.59	<.0001****
COVID-19 worry ^b					
No worry	0.01	-0.21	0.22	0.00	0.94
Much of time	0.36	0.12	0.59	0.04	0.003**
Most of time	0.99	0.57	1.40	0.06	<.0001****
Adj R²=.56, n=3090					

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

^a Comparison reference group “I am in neither risk category”.

^b Comparison reference group “I occasionally worry about getting COVID-19”

Appendix 3: Summary of modifiable and non-modifiable explanatory factors considered in the analysis

Table S16: Explanatory factors considered in the analysis

	Question/scale	Response(s)
Non-modifiable factors		
Gender*	What was your gender at birth?	Male Female Other Prefer not to say
Age	How old are you?	..
Ethnicity*	What is your ethnicity	White – British, Irish, other Asian/Asian British – Indian, Pakistani, Bangladeshi, other Black/Black British – Caribbean, African, other Chinese/Chinese British Mixed race – White and Black/Black British Middle Eastern/Middle Eastern British – Arab, Turkish, other Mixed race – other Other ethnic group Prefer not to say
Key-worker status	Are you currently fulfilling any of the government’s identified ‘key worker’ roles?	Health, social care ore relevant related support worker Teacher or childcare worker still travelling in to work Transport worker still travelling in to work Food chain worker (e.g. production, sale, delivery) Key public services worker (e.g. justice staff, religious staff, public service journalist or mortuary worker) Local or national government worker delivering essential public services Utility worker (e.g. energy, sewerage, postal service) Public safety or national security worker Worker involved in medicines or protective equipment production or distribution

		Other 'key worker' role not listed
		None of these
Living alone/with others	Do you live with someone?	Yes No
Recognised risk group for COVID-19	Which of these 3 COVID-19 risk groups do you think you are in?	I am most at risk (e.g., suffering from advanced cancer, severe asthma/COPD, etc.) I am at increased risk (e.g., being pregnant, aged over 70, etc.) I am in neither risk category.
Modifiable factors		
<i>Perceived loneliness</i> [†]	On a scale of 1-10, how lonely have you felt over the past 2 weeks?	1 (Not at all lonely) - 10 (Extremely lonely)
<i>Perceived risk of COVID-19</i>	On a scale of 1-10, what do you believe your risk of getting COVID-19 is?	1 (I don't think I will get it) - 10 (I know I will most certainly get it)
<i>Positive mood</i> [‡]	In the past 2 weeks, I have felt Positive.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
	In the past 2 weeks, I have felt Good.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
	In the past 2 weeks, I have felt Pleasant.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
	In the past 2 weeks, I have felt Happy.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
	In the past 2 weeks, I have felt Joyful.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
<i>COVID-19 worry</i>	In the past 2 weeks, I have felt Contented.	1=Very rarely or never/ 2=Rarely/ 3=Sometimes/ 4=Often/ 5=Very often or always
	Please read the following statements carefully and then select the one which best describe how you have felt over the past 2 weeks.	I do not worry about getting COVID-19.
		I occasionally worry about getting COVID-19.
		I spend much of my time worrying about getting COVID-19.
		I spend most of my time worrying about getting COVID-19.

*Gender and ethnicity were treated as binary variables in all analyses: gender (male, female), ethnicity (white British, non-white British).

[†] The factors in *Italic* were hypothesised to be associated with an increased risk of adverse mental health outcomes, apart from key-worker status where evidence exists that some key-worker roles are also associated with an increased risk of adverse COVID-19 outcomes. All other factors were hypothesised to be associated with an increased risk of contracting COVID-19 and/or poorer disease outcomes.

[‡]Positive mood was measured using the positive items from SPANE: Scale of Positive and Negative Experience ($\alpha=0.94$).²⁵

Appendix 4: Means for depression, anxiety and stress with overall means weighted to mid-2019 UK population distribution

Table S17: Means for depression, anxiety and stress scores with overall means weighted to UK mid-2019 population distribution

	Number	Depression (PHQ-9) score	Anxiety (GAD-7) score	Stress (PSS-4) score
		Participants	Participants	Participants
		Mean	Mean	Mean
Males				
Age group				
18-19	9	8.11	4.67	5.11
20-24	68	9.88	7.49	7.06
25-29	42	8.12	6.24	6.55
30-34	34	7.94	6.82	6.53
35-39	42	6.40	5.88	5.74
40-44	51	7.04	5.59	5.90
45-49	37	7.14	6.30	6.46
50-54	43	6.51	4.56	6.07
55-59	42	5.64	5.17	6.00
60-64	29	5.07	4.03	5.21
65-69	40	2.03	1.83	4.05
70-74	24	2.46	2.08	4.63
75-79	7	1.71	1.57	3.71
80+	8	3.25	1.90	3.55
Overall¹	476	6.08	4.91	5.68
Females				
Age group				
18-19	35	9.29	8.37	7.57
20-24	252	11.99	9.68	8.60
25-29	215	9.13	7.84	7.01
30-34	237	8.62	8.03	7.00
35-39	266	9.05	8.12	7.20
40-44	277	7.95	6.94	6.47
45-49	299	7.91	6.58	6.38
50-54	311	6.90	6.23	5.92
55-59	298	6.80	5.98	6.20
60-64	201	6.01	4.88	5.63
65-69	127	4.68	3.98	5.59
70-74	66	3.77	3.41	4.83
75-79	24	4.75	3.42	5.42
80+	9	4.00	2.07	6.15
Overall¹	2617	7.32	6.18	6.36
Overall: Males and females¹		6.71	5.56	6.03

¹ Overall means weighted to mid-year population distribution of UK for 2019