BMJ Open

Mental health in the UK during the COVID-19 pandemic

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-040620
Article Type:	Original research
Date Submitted by the Author:	18-May-2020
Complete List of Authors:	Jia, Ru; University of Nottingham Division of Primary Care Ayling, Kieran; University of Nottingham Division of Primary Care Chalder, Trudie; King's College London, PSYCHOLOGICAL MEDICINE Massey, Adam; University of Nottingham Division of Primary Care Broadbent, E; The University of Auckland Faculty of Medical and Health Sciences Coupland, Carol; University of Nottingham Faculty of Medicine and Health Sciences, Division of Primary Care Vedhara, Kavita; University of Nottingham Faculty of Medicine and Health Sciences
Keywords:	MENTAL HEALTH, PSYCHIATRY, PUBLIC HEALTH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Mental health in the UK during the COVID-19 pandemic

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

[1]Ru Jia MSc [Research Assistant],

[1]Kieran Ayling PhD [Senior Research Fellow],

[2]Trudie Chalder PhD [Professor of Cognitive Behavioural Psychotherapy],

[1]Adam Massey PhD [Honorary Research Associate],

[3]Elizabeth Broadbent PhD [Professor in Health Psychology],

[1]Carol Coupland PhD [Professor of Medical Statistics],

[1*]Kavita Vedhara PhD [Professor of Health Psychology]

[1]Division of Primary Care

University of Nottingham

University Park

Nottingham, NG7 2RD

[2]Department of Psychological Medicine,

Institute of Psychiatry, Psychology & Neuroscience,

King's College London,

16, De Crespigny Park,

London, SE5 8AF,

United Kingdom.

[3]Department of Psychological Medicine,

University of Auckland,

Private bag 92019, Auckland,

New Zealand.

* Author to whom all correspondence should be addressed: Professor Kavita Vedhara, Division of Primary Care, University of Nottingham, University Park, Nottingham, NG7 2RD, UK.
Kavita.vedhara@nottingham.ac.uk; Tel +44 115 8466931

Abstract

Objectives: Previous pandemics have resulted in significant consequences for mental health. Here we report the mental health sequela of the COVID-19 pandemic on the UK population and examine modifiable and non-modifiable explanatory factors associated with mental health outcomes. We focus on the 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=254) 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.

Results: Mean scores for depression, stress and anxiety significantly exceeded population norms (all $p<0{\cdot}0001$). Analysis of non-modifiable factors hypothesised to be associated with mental health outcomes indicated that being younger and female were associated with increased stress, anxiety and depression, with the final multivariable models accounting for 7-13% 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 variance.

Conclusions: Increased psychological morbidity was evident in this UK cohort, with younger people and women at particular risk. Interventions targeting perceptions of loneliness, risk of COVID-19, worry about COVID-19, and 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, as well as potential psychological targets for future 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. Understanding these factors will be critical in determining who is at greatest risk of mental health difficulties and potential approaches to intervention. We report here cross-sectional findings from a community cohort study designed to capture both the mental health sequela 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 mental health will be profound and far reaching.[1] Evidence on the impact of the pandemic on people living in China attests to this possibility.[2,3] , as does the experience of previous pandemics.[4,5] Indeed, preliminary evidence from the UK suggests that these experiences may be replicated here. [1,6] 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. [7,8] 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.[9] Recent UK data also suggest that key-workers, in particular those in social care, are at greater risk of COVID-19 related mortality. [7]

The aforementioned factors are, however, largely non-modifiable. Do modifiable risk factors exist which could be targets for intervention? Stress and coping theory.[10] 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.[11-13] 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.[14,15] 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.[10,16] 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.[17,18]

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 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.covidstressstudy.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. 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.

Procedures

Consenting participants completed an online survey implemented through JISC Online Survey (https://www.onlinesurveys.ac.uk/). This included validated measures capturing the mental health outcomes: anxiety (α=0·88), depression (α=0·92) and stress (α=0·76).[19-22] 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).

Statistical analysis

We first summarised the outcome variables (depression, anxiety and stress) and participant characteristics with appropriate summary statistics and examined histograms and scatterplots. To explore the associations between non-modifiable and modifiable explanatory factors on outcome variables we conducted univariable linear regression analyses (see supplementary appendix). Multivariable linear regression analyses were then used to explore the independent relationships of non-modifiable factors (age, gender, ethnicity, keyworker status, living alone) 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. Square root transformations were used for depression and anxiety scores to satisfy assumptions. Robustness of the models were 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).

For depression and anxiety we carried out additional analyses dichotomising according to established cut-offs (scores of 10 or greater indicating moderate or severe levels). 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 and reveals that our sample was predominantly female; with a mean age of 44 years (standard deviation=15); with participation across the UK (albeit primarily from England) 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)

	Participants
	n (%)
Gender	
Male	476 (15·4%)
Female	2618 (84·5%)
Prefer not to say	3 (0·1%)
Age groups (years)	
18-24	363 (11·7%)

25-34	528 (17·1%)
35-44	635 (20·5%)
45-54	687 (22·2%)
55-64	568 (18·3%)
65-74	254 (8·2%)
≥75	62 (2·0%)
Ethnicity	
White – British, Irish, other	2796 (90·3%)
Asian/Asian British – Indian, Pakistani, Bangladeshi, other	119 (3·8%)
Black/Black British – Caribbean, African, other	42 (1·4%)
Chinese/Chinese British	28 (0·9%)
Mixed race – White and Black/Black British	19 (0·6%)
Middle Eastern/Middle Eastern British – Arab, Turkish, other	23 (0·7%)
Mixed race – other	40 (1·3%)
Other ethnic group	25 (0·8%)
Prefer not to say	5 (0·2%)
Relationship status	
Single, never married	574 (18·5%)
Single, divorced or widowed	263 (8·5%)
In a relationship/married but living apart	254 (8·2%)
In a relationship/married and cohabiting	1981 (64·0%)
Prefer not to say	25 (0·8%)
Education (highest level of attainment)	
No qualifications	33 (1·1%)
Completed GSCE/CSE/O-levels or equivalent	252 (8·1%)
Completed post-16 vocational course	101 (3·3%)
A-levels or equivalent (at school until aged 18)	403 (13·0%)
Undergraduate degree or professional qualification	1306 (42·2%)
Postgraduate degree	976 (31·5%)
Prefer not to say	26 (0·8%)
Place of residence	
South West England	241 (7·8%)
East Midlands	762 (24·6%)
Yorkshire and Humber	293 (9·5%)
North East	147 (4·8%)
East of England	153 (4·9%)
North West	357 (11·5%)
South East England	415 (13·4%)
Greater London	329 (10·6%)
West Midlands	165 (5·3%)
Northern Ireland	8 (0·3%)
Wales	73 (2·4%)
Scotland	154 (5·0%)
Key-worker status	

Health, social care or relevant related support worker	1198 (38·7%)
Teacher or childcare worker still travelling in to work	70 (2·3%)
Transport worker still travelling in to work	1 (0·03%)
Food chain worker (e.g. production, sale, delivery)	33 (1·1%)
Key public services worker (e.g. justice staff, religious staff, public service journalist or mortuary worker)	22 (0·7%)
Local or national government worker delivering essential public services	41 (1·3%)
Utility worker (e.g. energy, sewerage, postal service)	5 (0·2%)
Public safety or national security worker	11 (0·4%)
Worker involved in medicines or protective equipment production or distribution	10 (0·3%)
Other key worker role not listed	168 (5·4%)
Not a key worker	1538 (49·7%)
Living alone (or with others)	
Living alone	406 (13·1%)
Living with others	2691 (86·9%)
COVID-19 risk status	
Most at risk (e.g. suffering from advanced cancer, severe asthma/COPD, etc.)	121 (3·9%)
At increased risk (e.g., being pregnant, aged over 70, etc.)	528 (17·1%)
Not at-risk	2448 (79·0%)

Mental health outcomes

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 norms[23-25]. 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.

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		Participants	Norms		Participants	Norms	
	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t
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 (p=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 (p=0·084)
Age groups (years)									
18-24	11·26 (6·4)	..	..	9·04 (5·9)	..	..	7·64 (3·3)	..	..
25-34	8·74 (5·9)	2·3 (3·2)	22·46****	7·73 (5·6)	2·81 (3·3)	13·85****	6·97 (3·3)	..	..
35-44	8·24 (6·0)	2·6 (3·5)	23·48****	7·25 (5·7)	2·82 (3·3)	14·09****	6·40 (3·1)	..	..
45-54	7·34 (5·7)	2·8 (3·5)	19·31****	6·28 (5·3)	3·14 (3·4)	10·71****	6·06 (3·1)	..	..
55-64	6·32 (5·6)	3·2 (3·5)	12·90****	5·43 (5·1)	3·25 (3·6)	7·36****	5·40 (3·1)	..	..
65-74	3·81 (4·2)	3·3 (3·6)	1·88 (p=0·060)	3·33 (3·8)	2·79 (3·2)	1·95 (p=0·052)	4·83 (2·9)	..	..
≥75	4·69 (5·7)	4·4 (3·9)	0·29 (p=0·61)	3·26 (4·4)	3·05 (3·4)	0·37 (p=0·71)	5·22 (3·1)	..	..

† PHQ-9, the 9-item Patient Health Questionnaire;[19] GAD-7, the 7-item Generalized Anxiety Disorder Scale;[20] PSS-4, the 4-item Perceived Stress Scale.[21] Published population normative data for PHQ-9[23], GAD-7[25], PSS-4[24].
**** p<0·0001, *** p<0·001, ** p<0·01, * p<0·05

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

		Whole sample		Male		Female	
Categories		**n**	**%**	**n**	**%**	**n**	**%**
Depression (PHQ-9[‡]**)**	*No-Minimal Depression (0-4)*	1125	36·3	230	48·3	894	34·1
	Mild Depression (5-9)	994	32·1	125	26·3	868	33·2
	Moderate Depression (10-14)	525	17·0	64	13·4	461	17·6
	Moderately Severe Depression (15-19)	276	8·9	35	7·4	241	9·2
	Severe Depression (20-27)	177	5·7	22	4·6	154	5·9
Anxiety (GAD-7[‡]**)**	*No-Minimal Anxiety (0-4)*	1344	43·4	276	58·0	1066	40·7
	Mild Anxiety (5-9)	947	30·6	108	22·7	839	32·0
	Moderate Anxiety (10-14)	430	13·9	44	9·2	386	14·7
	Severe Anxiety (15-21)	376	12·1	48	10·1	327	12·5

[†] Cut-offs for categories in line with published guidelines for PHQ-9[23] 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=-0·28, 95% CI:-0·31, -0·25 per decade), female (B=0·36, 95% CI: 0·25, 0·47) and living alone (B=0·34, 95% CI: 0·25, 0·47) were all independently significantly associated with greater levels of depression. This model accounted for approximately 13% 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 females having a 49% increased odds of depression and living alone associated with a 55% increase.

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

	B	95% CI Lower	95% CI Upper	*β*	*p*
PHQ-9 Total Score [a]					
Age (per decade)	-0·28	-0·31	-0·25	-0·35	<·0001****
Female	0·36	0·25	0·47	0·11	<·0001****
Live alone	0·34	0·22	0·46	0·09	<·0001****
BAME background	0·03	-0·11	0·17	0·01	·64
Key-worker	0·06	-0·02	0·14	0·02	·15
Adjusted R^2=0·13, n=3090					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	*β*	*p*
PHQ-9 "Cases" [b]					
Age (per decade)	0·67	0·63	0·71	-1·30	<·0001****
Female	1·49	1·18	1·89	0·31	·00079***
Live alone	1·55	1·23	1·97	0·32	·00025***
BAME background	1·14	0·88	1·48	0·08	·32
Key-worker	1·14	0·97	1·33	0·14	·11
Pseudo R^2=0·06, 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] 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=-0·24, 95% CI: -0·27, -0·22 per decade) and female (B=0·43, 95% CI: 0·32, 0·55) were independently significantly associated with greater levels of anxiety (Table 5). This model accounted for approximately 11% of the variance and these results were replicated when considering anxiety as a binary outcome (i.e., cases requiring high intensity intervention versus not).

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)	-0·24	-0·27	-0·22	-0·30	<·0001****
Female	0·43	0·32	0·55	0·13	<·0001****
Live alone	-0·03	-0·15	0·09	-0·01	·64
BAME background	0·02	-0·12	0·16	0·01	·77
Key-worker	0·08	-0·00	0·16	0·03	·06
Adjusted R^2=0·11, n=3090					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	*β*	*p*
GAD-7 "Cases" [b]					
Age (per decade)	0·70	0·66	0·74	-1·23	<·0001****
Female	1·61	1·25	2·08	0·39	0·00020***
Live alone	1·02	0·78	1·32	0·01	·91
BAME background	1·15	0·88	1·51	0·10	·30
Key-worker	1·13	0·96	1·34	0·14	·15
Pseudo R^2=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] 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, being younger (B=-0·54, 95% CI: -0·61, -0·46 per decade), female (B=0·78, 95% CI: 0·46, 1·09), living alone (B=0·48, 95% CI: 0·15, 0·82), being from a BAME background (B=0·45, 95% CI: 0·07, 0·84), were all independently significantly associated with greater stress; while being a key-worker was independently significantly associated with a lower stress (B=-0·24, 95% CI: -0·47, -0·02). Together the model accounted for approximately 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*	*p*
PSS-4 Total Score					
Age (per decade)	-0·54	-0·61	-0·46	-0·25	<·0001****
Female	0·78	0·46	1·09	0·09	<·0001****
Live alone	0·48	0·15	0·82	0·05	0·0049**
BAME background	0·45	0·07	0·84	0·04	0·022*
Key-worker	-0·24	-0·47	-0·02	-0·04	0·033*
Adjusted R^2=0·07, n=3090					

**** p<0·0001, *** p<0·001, ** p<0·01, * p<0·05

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 levels of 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)	5·36 (2·7)	4·36 (2·7)	3·76 (2·7)	3·62 (2·8)	3·47 (2·7)	2·70 (2·1)	2·71 (2·4)
Positive mood										
Mean (SD)	18·99 (5·1)	19·76 (5·1)	18·85 (5·0)	17·67 (4·9)	18·82 (5·1)	18·67 (5·0)	18·92 (5·1)	19·38 (5·0)	20·72 (4·6)	21·56 (5·2)
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)	5·15 (2·2)	5 (2·2)	4·78 (2·3)	4·21 (2·1)	3·31 (1·9)
Worry about COVID-19										
No worry (n, %)	512 (16·5%)	105 (22·1%)	406 (15·5%)	105 (28·9%)	108 (20·5%)	91 (14·3%)	91 (13·3%)	65 (11·4%)	39 (15·4%)	13 (21·0%)
Occasional worry (n, %)	2050 (66·2%)	318 (66·8%)	1731 (66·1%)	208 (57·3%)	320 (60·6%)	427 (67·2%)	466 (67·8%)	396 (69·7%)	188 (74·0%)	45 (72·6%)
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 (15·0%)	24 (9·5%)	3 (4·8%)
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 (1·6%)

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=0·28, 95% CI: 0·18, 0·38; most of time: B=0·32, 95% CI: 0·13, 0·50), were all independently and significantly associated with greater levels of depression, in addition to age and gender. The model accounted for approximately 56% of the variance in depression scores. While perceived risk of COVID-19 was not statistically significant, in sensitivity analyses where large residuals were excluded (<-3/>3) this became statistically significant (B=0·02, 95% CI: 0·00, 0·03). These results were largely replicated when considering depression as a binary outcome although gender was 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)	-0·18	-0·20	-0·15	-0·22	<·0001****
Female	0·18	0·09	0·27	0·05	<·0001****
Live alone	0·02	-0·08	0·12	0·01	0·71
BAME background	-0·03	-0·14	0·08	-0·01	0·61
Key-worker	0·01	-0·06	0·08	0·00	0·84
Perceived loneliness (per unit)	0·10	0·09	0·12	0·23	<·0001****
Positive mood (per unit)	-0·12	-0·12	-0·11	-0·48	<·0001****
COVID-19 worry [b]					
No worry	-0·01	-0·10	0·09	-0·00	0·89
Much of time	0·28	0·18	0·38	0·08	<·0001****
Most of time	0·32	0·13	0·50	0·05	0·00067***
Perceived risk of COVID-19 (per unit)	0·01	-0·00	0·03	0·02	0·13
Adjusted R^2=0·56, n=2494					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	***β***	***p***
PHQ-9 "Cases" [c]					
Age (per decade)	0·68	0·63	0·74	-1·30	<·0001****
Female	1·06	0·76	1·47	0·04	0·75
Live alone	0·88	0·61	1·25	-0·10	0·46
BAME background	0·95	0·65	1·39	-0·03	0·79
Key-worker	1·07	0·85	1·36	0·08	0·57
Perceived loneliness (per unit)	1·22	1·17	1·28	1·20	<·0001****
Positive mood (per unit)	0·76	0·74	0·79	-3·02	<·0001****
COVID-19 worry [b]					
No worry	1·00	0·71	1·41	0·00	0·98
Much of time	1·74	1·28	2·36	0·41	0·00037***
Most of time	2·08	1·17	3·72	0·30	0·013*
Perceived risk of COVID-19 (per unit)	1·04	0·98	1·09	0·17	0·23
Pseudo R^2=0·35, 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 occasionally worry about getting COVID-19".

[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, 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=0·58, 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=-0·19, 95% CI: -0·28, -0·09). The model accounted for approximately 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*	*p*
GAD-7 Total Score [a]					
Age (per decade)	-0·16	-0·18	-0·13	-0·19	<·0001****
Female	0·25	0·15	0·34	0·07	<·0001****
Live alone	-0·25	-0·35	-0·15	-0·07	<·0001****
BAME background	-0·08	-0·20	0·03	-0·02	0·17
Key-worker	-0·04	-0·11	0·03	-0·02	0·27
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 [b]					
No worry	-0·19	-0·28	-0·09	-0·05	0·00015***
Much of time	0·58	0·47	0·68	0·16	<·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 R^2=·54, n=2494					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	***β***	***p***
GAD-7 "Cases" [c]					
Age (per decade)	0·69	0·63	0·75	-1·34	<·0001****
Female	1·17	0·82	1·67	0·14	0·37
Live alone	0·67	0·46	0·99	-0·32	0·044*
BAME background	0·96	0·65	1·43	-0·03	0·85
Key-worker	0·90	0·70	1·15	-0·13	0·40
Perceived loneliness (per unit)	1·11	1·06	1·17	0·67	<·0001****
Positive mood (per unit)	0·77	0·75	0·80	-3·07	<·0001****
COVID-19 worry [b]					
No worry	0·75	0·52	1·09	-0·24	0·14
Much of time	3·86	2·86	5·22	1·06	<·0001****
Most of time	11·57	5·88	22·77	1·06	<·0001****
Perceived risk of COVID-19 (per unit)	1·07	1·01	1·14	0·35	0·024*
Pseudo R^2=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 occasionally worry about getting COVID-19".

[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.

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 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 approximately 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*	*p*
PSS-4 Total Score					
Age (per decade)	-0·24	-0·30	-0·18	-0·11	<·0001****
Female	0·35	0·12	0·59	0·04	0·0035**
Live alone	-0·41	-0·67	-0·14	-0·04	0·0025**
BAME background	0·26	-0·04	0·55	0·02	0·088
Key-worker	-0·40	-0·58	-0·21	-0·06	<·0001****
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	0·67
Much of time	0·37	0·10	0·63	0·04	0·0068**
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	0·0037**
Adjusted R^2=·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".

Discussion

We report findings from a community cohort study established in the UK to 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 recent population norms.[23-25] Models examining the relationship between these mental health outcomes and non-modifiable explanatory factors accounted for only a modest proportion of the variance (7-13%). Increased depression was associated with being younger, female and living alone; increased anxiety was associated with being younger and female; and increased stress was associated with being younger, female, living alone, being from a BAME background and not being a keyworker. In contrast, when we added the hypothesised modifiable variables into our multivariable models we observed that they accounted for a much larger proportion of the variance (54-57%) with significant independent effects emerging for positive mood, perceived loneliness and worry about getting COVID-19 for all three outcomes, as well as perceived risk of COVID-19 emerging as significant for anxiety and stress.

These findings highlight a number of issues worthy of discussion. First, both mean scores and measures of case-ness indicate that the COVID-19 pandemic is having widespread and deleterious effects on the emotional well-

being of people in the UK. This is true for depression, generalised anxiety disorder and stress and is in keeping with observations from other countries.[2,3] 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.[27] The prevalence of depression alone in the context of this pandemic is almost double this.

Second, the non-modifiable explanatory variables significantly associated with all three of our mental health outcomes were being younger and being female. These findings are consistent with unpublished data from another UK community cohort recruited during the COVID-19 pandemic with a similar gender profile to our own,[28] suggesting that these groups may be the most in need of intervention. Although this runs counter to our hypothesis that the greatest psychological morbidity would be observed in individuals at greatest risk of COVID-19, it is consistent with previous work which has shown that individual's perceptions of disease risk are often poorly related to actual risk.[29] Alternatively, the results may reflect the fact that the pandemic has resulted in a panoply of challenges to 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 third, and related issue, is that although being younger and female were consistently associated with poorer mental health, the relationship was modest, accounting for, at best, 13% of the variance. In contrast, the modifiable explanatory measures when added to the multivariable models accounted for 52-57% of the variance. These findings are encouraging as they suggest that there is considerable potential for us to develop interventions to mitigate the mental health effects of the pandemic. The measures of perceived loneliness, positive mood and worry about getting COVID-19 were strongly associated with all three outcomes and thus would be appropriate cognitions to be targeted in future interventions.[30]

A further 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.[31] 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.[32] 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.

Finally, we would like to acknowledge several limitations. These include the cross-sectional design of the work which impedes an analysis of cause and effect; the limited generalisability of our cohort inflicted by the self-selected community cohort design and the absence of information on pre-existing mental health conditions which are likely to impact on the severity and prevalence of psychological morbidity.[1] Nonetheless, 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; to identify groups who may be at particular risk, as well as potential targets for therapeutic intervention.

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.

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.

Acknowledgements and Funding

KA was supported by funding from the National Institute for Health Research School for Primary Care Research (NIHR SPCR). The views expressed are those of the author(s) and not necessarily those of the NIHR, the NHS or the Department of Health.

TC acknowledges the financial support of the Department of Health via the National Institute for Health Research (NIHR) Specialist Biomedical Research Centre for Mental Health award to the South London and Maudsley NHS Foundation Trust (SLaM) and the Institute of Psychiatry at King's College London. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care. No other funding supported the work described in this manuscript.

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

References

1. Holmes EA, O'Connor RC, Perry VH, et al. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science [published online ahead of print, 2020 Apr 15]. *Lancet Psychiatry*. 2020;S2215-0366(20)30168-1. doi:10.1016/S2215-0366(20)30168-1
2. Liu S, Yang L, Zhang C *et al*. Online mental health services in China during the COVID-19 outbreak. *Lancet Psychiatry* 2020; **18**:e17–e18 doi.org/10.1016/S2215-0366(20)30077-8
3. Tian F, Li H, Tian S, Yang J, Shao J, Tian C. Psychological symptoms of ordinary Chinese citizens based on SCL-90 during the level I emergency response to COVID-19 [published online ahead of print, 2020 Apr 11]. *Psychiatry Res*. 2020; 288-112992. doi:10.1016/j.psychres.2020.112992
4. Jeong H, Yim HW, Song YJ, et al. Mental health status of people isolated due to Middle East Respiratory Syndrome. *Epidemiol Health*. 2016; 38:e2016048. Published 2016 Nov 5. doi:10.4178/epih.e2016048
5. Chan SM, Chiu FK, Lam CW, Leung PY, Conwell Y. Elderly suicide and the 2003 SARS epidemic in Hong Kong. *Int J Geriatr Psychiatry*. 2006; **21** (2):113–118. doi:10.1002/gps.1432
6. Williams SN, Armitage CJ, Tampe T, Dienes K. Public perceptions and experiences of social distancing and social isolation during the COVID-19 pandemic: A UK-based focus group study. medRxiv 2020 doi: https://doi.org/10.1101/2020.04.10.20061267 (preprint)
7. https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/coronaviruscovid19relateddeathsbyoccupationenglandandwales/deathsregistereduptoandincluding20april2020 [accessed 11/05/20]
8. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study; [published correction appears in Lancet. 2020 Mar 28;395(10229):1038]. *Lancet*. 2020; **395** (10229):1054-1062. doi:10.1016/S0140-6736(20)30566-3
9. Khunti K, Singh AK, Pareek M, Hanif W. Is ethnicity linked to incidence or outcomes of covid-19? *BMJ*. 2020; 369:m1548. Published 2020 Apr 20. doi:10.1136/bmj.m1548
10. Folkman S. 1997. Positive psychological states and coping with severe stress. *Soc. Sci. Med*. **45**:1207–21

11. Bults M, Beaujean DJ, de Zwart O, et al. Perceived risk, anxiety, and behavioural responses of the general public during the early phase of the Influenza A (H1N1) pandemic in the Netherlands: results of three consecutive online surveys. *BMC Public Health*. 2011; 11:2. Published 2011 Jan 3. doi:10.1186/1471-2458-11-2.

12. Salkovskis PM, Rimes KA, Warwick HM, Clark DM. The Health Anxiety Inventory: development and validation of scales for the measurement of health anxiety and hypochondriasis. *Psychol Med*. 2002; **32**(5):843-853. doi:10.1017/s0033291702005822

13. Gao J, Zheng P, Jia Y, et al. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS One*. 2020; **15**(4):e0231924. Published 2020 Apr 16.doi:10.1371/journal.pone.0231924

14. Wang J, Mann F, Lloyd-Evans B, Ma R, Johnson S. Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC Psychiatry*. 2018; 18(1):156. Published 2018 May 29. doi:10.1186/s12888-018-1736-5

15. Leigh-Hunt N, Bagguley D, Bash K, Turner V, Turnbull S, Valtorta N, Caan W. An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public Health*. 2017 Nov; 152:157-171. doi: 10.1016/j.puhe.2017.07.035.

16. Pressman SD, Jenkins BN, Moskowitz JT. Positive Affect and Health: What Do We Know and Where Next Should We Go? *Ann Rev Psychol*. 2019; **70**:627-650. doi:10.1146/annurev-psych-010418-102955

17. Schotanus-Dijkstra M, ten Have M, Lamers SMA, de Graaf R, Bohlmeijer ET. The longitudinal relationship between flourishing mental health and incident mood, anxiety and substance use disorders. *Eur J Public Health*. 2017; **27**(3):563-568. doi:10.1093/eurpub/ckw202

18. Schotanus-Dijkstra M, Keyes CLM, de Graaf R, ten Have M. Recovery from mood and anxiety disorders: The influence of positive mental health. *J Affect Disord*. 2019; **252**:107-113. doi:10.1016/j.jad.2019.04.051

19. Kroenke K, Spitzer RL, Williams JB, Lowe B. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. *Gen Hosp Psychiatry*. 2010;**32**(4):345–59

20. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med*. 2006; 166(10):1092–1097. doi:10.1001/archinte.166.10.1092

21. Cohen S, Williamson G. (1988). Perceived Stress in a Probability Sample of the United States. In S. Spacapam & S. Oskamp (Eds.), The social psychology of health: Claremont Symposium on Applied Social Psychology (pp. 31–67). Newbury Park, CA: Sage.

22. Diener E., Wirtz D, Tov W, et al. (2010). New well-being measures: Short scales to assess flourishing, positive, and negative feelings. *Social Indicators Research*, **97**(2), 143–156. https://doi.org/10.1007/s11205-009-9493-y

23. Kocalevent RD, Hinz A, Brähler E. Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *Gen Hosp Psychiatry*. 2013; **35** (5):551-555. doi:10.1016/j.genhosppsych.2013.04.006

24. Warttig SL, Forshaw MJ, South J, White AK. New, normative, English-sample data for the Short Form Perceived Stress Scale (PSS-4). *J Health Psychol*. 2013; **18**(12):1617-1628. doi:10.1177/1359105313508346

25. Löwe B, Decker O, Müller S, et al. Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Med Care*. 2008**; 46** (3):266-274. doi:10.1097/MLR.0b013e318160d093.

26. https://www.rcpsych.ac.uk/docs/default-source/improving-care/nccmh/iapt/the-iapt-manual--final--republished-7-3-18.pdf?sfvrsn=a192d1af_0 [accessed 5/5/20]

27. https://files.digital.nhs.uk/pdf/q/3/mental_health_and_wellbeing_in_england_full_report.pdf [accessed 03/05/20]

28. https://www.marchnetwork.org/research [accessed 04/05/20]

29. Westhoff CL. Breast cancer risk: perception versus reality. *Contraception*. 1999; **59** (1 Suppl):25S-28S. doi:10.1016/s0010-7824(98)00134-6

30. Masi CM, Chen HY, Hawkley LC, Cacioppo JT. A meta-analysis of interventions to reduce loneliness. *Per Soc Psychol Rev*. 2011; **15** (3):219-266. doi:10.1177/1088868310377394

31. O'Connor D, Thayer J, Vedhara K. Stress and Health: A Review of Psychobiological Processes. *Annual Review of Psychology* (in press).

32. https://thepsychologist.bps.org.uk/we-will-have-live-risk-covid-19-psychology-has-much-say-about-risk [accessed 06/05/2020]

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: Boxplots of outcome variables

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)
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)
Constant	3·68**** (0·06)	2·18**** (0·06)	2·47**** (0·02)	2·47**** (0·02)	2·43**** (0·03)

**** $p<0·0001$, *** $p<0·001$, ** $p<0·01$, * $p<0·05$

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]
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]
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]

**** $p<0·0001$, *** $p<0·001$, ** $p<0·01$, * $p<0·05$

[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

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)
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)
Constant	3·34**** (0·07)	1·87**** (0·06)	2·28**** (0·02)	2·23**** (0·02)	2·17**** (0·03)

**** $p<0·0001$, *** $p<0·001$, ** $p<0·01$, * $p<0·05$

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]
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]
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]

**** $p<0·0001$, *** $p<0·001$, ** $p<0·01$, * $p<0·05$

[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

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)
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)
Constant	8·84**** (0·18)	5·88**** (0·15)	6·46**** (0·06)	6·40**** (0·06)	6·53**** (0·08)

**** $p<0·0001$, *** $p<0·001$, ** $p<0·01$, * $p<0·05$

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*	*p*
PHQ-9 Total Score [a]					
Age (per decade)	-0·17	-0·19	-0·15	-0·21	<·0001****
Female	0·19	0·11	0·27	0·06	<·0001****
Live alone	-0·00	-0·09	0·09	-0·00	0·99
BAME background	-0·06	-0·16	0·04	-0·01	0·25
Key-worker	0·06	-0·00	0·11	0·02	0·059
Perceived loneliness	0·10	0·08	0·11	0·22	<·0001****
Positive mood	-0·12	-0·13	-0·11	-0·49	<·0001****
COVID-19 worry [b]					
No worry	0·02	-0·06	0·10	0·01	0·61
Much of time	0·29	0·20	0·37	0·08	<·0001****
Most of time	0·35	0·20	0·50	0·06	<·0001****
Adj R^2=·56, F(10,3079)=389·21, *p*<·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 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*	*p*
PHQ-9 "Cases" [a]					
Age (per decade)	0·69	0·64	0·74	-1·19	<·0001****
Female	1·19	0·89	1·59	0·13	0·24
Live alone	0·84	0·62	1·16	-0·12	0·29
BAME background	0·97	0·70	1·36	-0·02	0·88
Key-worker	1·20	0·99	1·46	0·20	0·069
Perceived loneliness	1·21	1·16	1·26	1·13	<·0001****
Positive mood	0·76	0·74	0·78	-2·96	<·0001****
COVID-19 worry [b]					
No worry	0·91	0·69	1·22	-0·07	0·54
Much of time	1·64	1·26	2·13	0·36	0·00025***
Most of time	2·66	1·60	4·45	0·41	0·00018***
Pseudo R^2=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 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*	*p*
GAD-7 Total Score [a]					
Age (per decade)	-0·16	-0·18	-0·14	-0·19	<·0001****
Female	0·24	0·16	0·33	0·07	<·0001****
Live alone	-0·27	-0·36	-0·17	-0·07	<·0001****
BAME background	-0·08	-0·18	0·02	-0·02	0·13
Key-worker	0·04	-0·02	0·10	0·02	0·22
Perceived loneliness	0·06	0·05	0·07	0·14	<·0001****
Positive mood	-0·12	-0·12	-0·11	-0·48	<·0001****
COVID-19 worry [b]					
No worry	-0·19	-0·28	-0·11	-0·06	<·0001****
Much of time	0·57	0·48	0·67	0·16	<·0001****
Most of time	0·88	0·71	1·04	0·14	<·0001****
Adj R^2=·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 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*	*p*
GAD-7 "Cases" [a]					
Age (per decade)	0·69	0·64	0·75	-1·26	<·0001****
Female	1·23	0·91	1·68	0·17	0·18
Live alone	0·56	0·40	0·79	-0·45	0·00093***
BAME background	0·91	0·64	1·29	-0·06	0·60
Key-worker	1·11	0·90	1·36	0·12	0·33
Perceived loneliness	1·13	1·08	1·18	0·75	<·0001****
Positive mood	0·78	0·75	0·80	-2·90	<·0001****
COVID-19 worry [b]					
No worry	0·72	0·53	0·99	-0·27	0·041*
Much of time	3·55	2·73	4·61	0·98	<·0001****
Most of time	12·52	6·95	22·53	1·11	<·0001****
Pseudo R^2=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 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*	*p*
PSS-4 Total Score					
Age (per decade)	-0·24	-0·30	-0·19	-0·11	<·0001****
Female	0·30	0·09	0·52	0·03	0·0056**
Live alone	-0·37	-0·61	-0·12	-0·04	0·0030**
BAME background	0·21	-0·06	0·47	0·02	0·13
Key-worker	-0·25	-0·41	-0·10	-0·04	0·0015**
Perceived loneliness	0·21	0·17	0·24	0·17	<·0001****
Positive mood	-0·38	-0·40	-0·36	-0·59	<·0001****
COVID-19 worry [a]					
No worry	0·00	-0·21	0·21	0·00	0·99
Much of time	0·37	0·13	0·60	0·04	0·0022**
Most of time	0·99	0·58	1·40	0·06	<·0001****
Adj R^2=·56, n=3090					

**** p<0·0001, *** p<0·001, ** p<0·01, * p<0·05

[a] 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
Modifiable factors		
Perceived loneliness†	On a scale of 1-10, how lonely have you felt over the past 2 weeks?	1 (Not at all lonely) - 10 (Extremely lonely)
Perceived risk of COVID-19	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)
Positive mood‡	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
Worry about contracting COVID-19	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 (α=0·94).[22]

Appendix 4: Boxplots of outcome variable scores by gender and age groups

Figure S1: Boxplot of depression (PHQ-9) scores

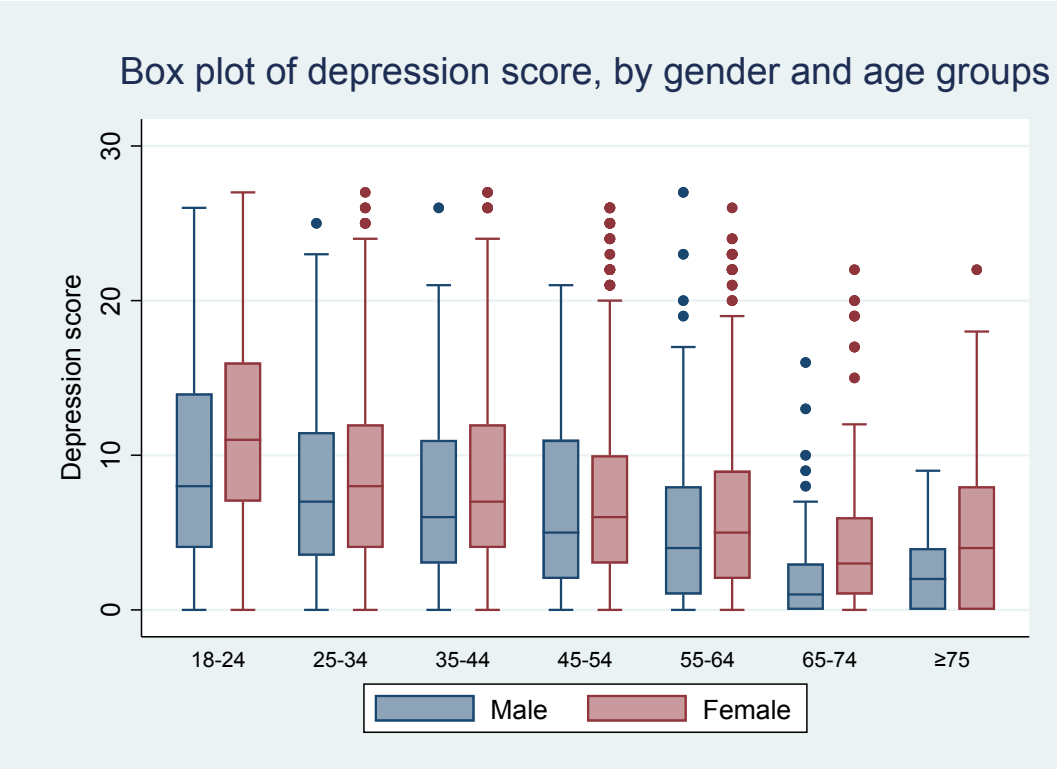

Figure S2: Boxplot of anxiety (GAD-7) scores

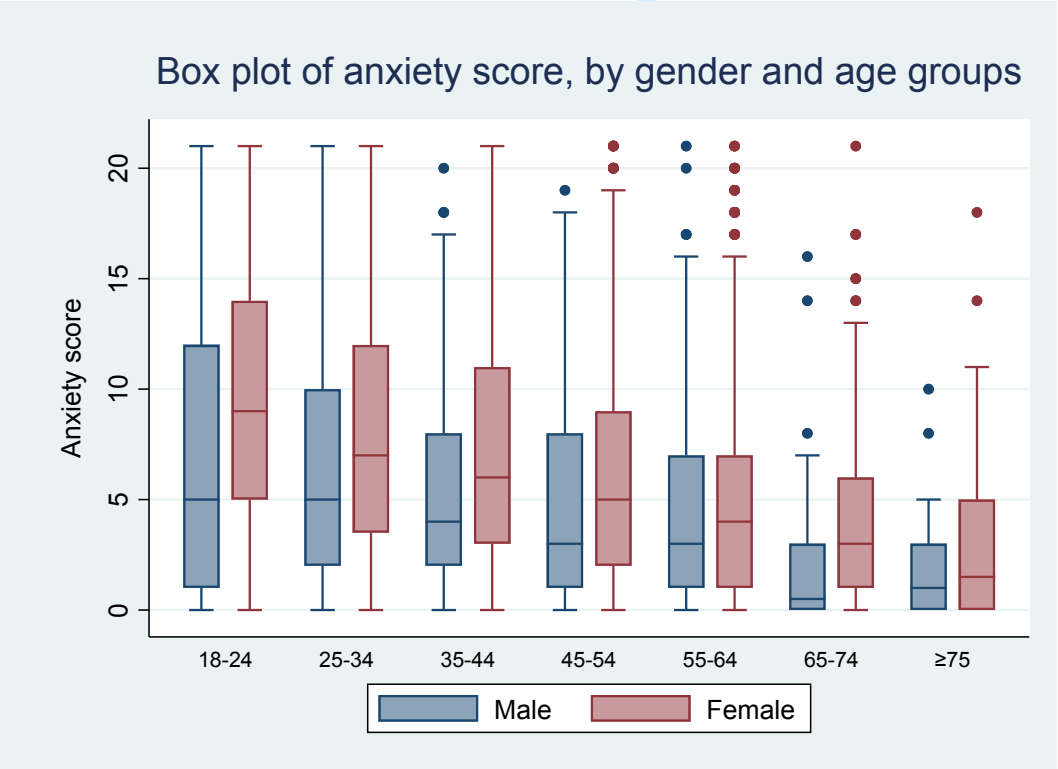

Figure S3: Boxplot of stress (PSS-4) scores

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	3,4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study Design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	
		Case-control study—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4, Supplement

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4, Supplement
Bias	9	Describe any efforts to address potential sources of bias	
Study Size	10	Explain how the study size was arrived at	
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	5, Supplement
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-8, supplemer
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	8-10

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-16
		(*b*) Report category boundaries when continuous variables were categorized	6-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-16, Supplem
Discussion			
Key Results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-040620.R1
Article Type:	Original research
Date Submitted by the Author:	28-Jul-2020
Complete List of Authors:	Jia, Ru; University of Nottingham Division of Primary Care Ayling, Kieran; University of Nottingham Division of Primary Care Chalder, Trudie; King's College London, PSYCHOLOGICAL MEDICINE Massey, Adam; University of Nottingham Division of Primary Care Broadbent, E; The University of Auckland Faculty of Medical and Health Sciences Coupland, Carol; University of Nottingham, Division of Primary Care Vedhara, Kavita; University of Nottingham, Division of Primary Care
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Epidemiology, Health services research, Public health
Keywords:	MENTAL HEALTH, PSYCHIATRY, PUBLIC HEALTH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

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

[1]Ru Jia MSc [Research Assistant],

[1]Kieran Ayling PhD [Senior Research Fellow],

[2]Trudie Chalder PhD [Professor of Cognitive Behavioural Psychotherapy],

[1]Adam Massey PhD [Honorary Research Associate],

[3]Elizabeth Broadbent PhD [Professor in Health Psychology],

[1]Carol Coupland PhD [Professor of Medical Statistics in Primary Care],

[1*]Kavita Vedhara PhD [Professor of Health Psychology]

[1]Division of Primary Care

University of Nottingham

University Park

Nottingham, NG7 2RD

[2]Department of Psychological Medicine,

Institute of Psychiatry, Psychology & Neuroscience,

King's College London,

16, De Crespigny Park,

London, SE5 8AF,

United Kingdom.

[3]Department of Psychological Medicine,

University of Auckland,

Private bag 92019, Auckland,

New Zealand.

* Author to whom all correspondence should be addressed: Professor Kavita Vedhara, Division of Primary Care, University of Nottingham, University Park, Nottingham, NG7 2RD, UK.
Kavita.vedhara@nottingham.ac.uk; Tel +44 115 8466931

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 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, as well as potential psychological targets for future 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 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.covidstressstudy.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/). This included validated measures capturing the mental health outcomes: anxiety (α=0.88), depression (α=0.92) and stress (α=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 large[26], 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%)	1,864890 (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 norms[27-29]. 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		Participants	Norms		Participants	Norms	
	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t
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 (p=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 (p=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 (p=0.051)	3.32 (3.8)	2.79 (3.2)	1.92 (p=0.056)	5.07 (3.0)	..	..
≥75	4.39 (5.8)	4.4 (3.9)	0.02 (p=0.99)	2.92 (4.4)	3.05 (3.4)	0.21 (p=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-9[27], GAD-7[29], PSS-4[28].

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

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

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

[†] Cut-offs for categories in line with published guidelines for PHQ-9[23] 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 R^2=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 R^2=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 R^2=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 R^2=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*	*p*
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 R^2=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 R^2=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 R^2=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*	*p*
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 R^2=.54, n=2494					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	***β***	***p***
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 R^2=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*	*p*
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 R^2=.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 a community cohort study established in the UK to 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; the absence of information on pre-existing mental health conditions which are likely to impact on the severity and prevalence

of psychological morbidity[1] and the limited generalisability of our cohort due to the self-selected community cohort design. Regarding the latter, several potential sources of sampling biases exist. This includes that the spread of participants across the UK was limited; and the potential for participants to be drawn to the research because of an interest in and experience of mental health difficulties. Thus, this group 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. 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 consistent with unpublished data from another UK community cohort recruited

during the COVID-19 pandemic with a similar gender profile to our own,[33] 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.[34] 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.[35] 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.[35] 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.

Acknowledgements and Funding

KA was supported by funding from the National Institute for Health Research School for Primary Care Research (NIHR SPCR). The views expressed are those of the author(s) and not necessarily those of the NIHR, the NHS or the Department of Health.

TC acknowledges the financial support of the Department of Health via the National Institute for Health Research (NIHR) Specialist Biomedical Research Centre for Mental Health award to the South London and Maudsley NHS Foundation Trust (SLaM) and the Institute of Psychiatry at King's College London. The views

expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care. No other funding supported the work described in this manuscript.

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

References

1. Holmes EA, O'Connor RC, Perry VH, et al. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The lancet Psychiatry* 2020;7(6):547-60. doi: 10.1016/s2215-0366(20)30168-1 [published Online First: 2020/04/19]

2. Candan SA, Elibol N, Abdullahi A. Consideration of prevention and management of long-term consequences of post-acute respiratory distress syndrome in patients with COVID-19. *Physiotherapy Theory and Practice* 2020;36(6):663-68. doi: 10.1080/09593985.2020.1766181

3. Liu S, Yang L, Zhang C, et al. Online mental health services in China during the COVID-19 outbreak. *The lancet Psychiatry* 2020;7(4):e17-e18. doi: 10.1016/s2215-0366(20)30077-8 [published Online First: 2020/02/23]

4. Tian F, Li H, Tian S, et al. Psychological symptoms of ordinary Chinese citizens based on SCL-90 during the level I emergency response to COVID-19. *Psychiatry research* 2020;288:112992. doi: 10.1016/j.psychres.2020.112992 [published Online First: 2020/04/18]

5. Jeong H, Yim HW, Song Y-J, et al. Mental health status of people isolated due to Middle East Respiratory Syndrome. *Epidemiol Health* 2016;38:e2016048-e48. doi: 10.4178/epih.e2016048

6. Chan SM, Chiu FK, Lam CW, et al. Elderly suicide and the 2003 SARS epidemic in Hong Kong. *International journal of geriatric psychiatry* 2006;21(2):113-8. doi: 10.1002/gps.1432 [published Online First: 2006/01/18]

7. Williams SN, Armitage CJ, Tampe T, et al. Public perceptions and experiences of social distancing and social isolation during the COVID-19 pandemic: a UK-based focus group study. *BMJ Open* 2020;10(7):e039334. doi: 10.1136/bmjopen-2020-039334

8. https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/coronaviruscovid19relateddeathsbyoccupationenglandandwales/deathsregistereduptoandincluding20april2020 [accessed 11/05/20].

9. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study; [published correction appears in Lancet. 2020 Mar 28;395(10229):1038]. . *The Lancet* 2020;395(10229):p1054-62.

10. Khunti K, Singh AK, Pareek M, et al. Is ethnicity linked to incidence or outcomes of covid-19? *BMJ* 2020;369:m1548. doi: 10.1136/bmj.m1548

11. Folkman S. Positive psychological states and coping with severe stress. *Social science & medicine (1982)* 1997;45(8):1207-21. doi: 10.1016/s0277-9536(97)00040-3 [published Online First: 1997/09/25]

12. Bults M, Beaujean DJ, de Zwart O, et al. Perceived risk, anxiety, and behavioural responses of the general public during the early phase of the Influenza A (H1N1) pandemic in the Netherlands: results of three consecutive online surveys. *BMC public health* 2011;11:2. doi: 10.1186/1471-2458-11-2 [published Online First: 2011/01/05]

13. Salkovskis PM, Rimes KA, Warwick HM, et al. The Health Anxiety Inventory: development and validation of scales for the measurement of health anxiety and hypochondriasis. *Psychological medicine* 2002;32(5):843-53. doi: 10.1017/s0033291702005822 [published Online First: 2002/08/13]

14. Gao J, Zheng P, Jia Y, et al. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS One* 2020;15(4):e0231924-e24. doi: 10.1371/journal.pone.0231924

15. Wang J, Mann F, Lloyd-Evans B, et al. Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC psychiatry* 2018;18(1):156. doi: 10.1186/s12888-018-1736-5 [published Online First: 2018/05/31]

16. Leigh-Hunt N, Bagguley D, Bash K, et al. An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public health* 2017;152:157-71. doi: 10.1016/j.puhe.2017.07.035 [published Online First: 2017/09/16]

17. Pressman SD, Jenkins BN, Moskowitz JT. Positive Affect and Health: What Do We Know and Where Next Should We Go? *Annual review of psychology* 2019;70:627-50. doi: 10.1146/annurev-psych-010418-102955 [published Online First: 2018/09/28]

18. Larsen JT, Hershfield HE, Stastny BJ, et al. On the relationship between positive and negative affect: Their correlation and their co-occurrence. *Emotion (Washington, DC)* 2017;17(2):323-36. doi: 10.1037/emo0000231 [published Online First: 2016/10/28]

19. Dejonckheere E, Mestdagh M, Verdonck S, et al. The relation between positive and negative affect becomes more negative in response to personally relevant events. *Emotion (Washington, DC)* 2019 doi: 10.1037/emo0000697 [published Online First: 2019/11/08]

20. Schotanus-Dijkstra M, Ten Have M, Lamers SMA, et al. The longitudinal relationship between flourishing mental health and incident mood, anxiety and substance use disorders. *Eur J Public Health* 2017;27(3):563-68. doi: 10.1093/eurpub/ckw202

21. Schotanus-Dijkstra M, Keyes CLM, de Graaf R, et al. Recovery from mood and anxiety disorders: The influence of positive mental health. *Journal of affective disorders* 2019;252:107-13. doi: 10.1016/j.jad.2019.04.051 [published Online First: 2019/04/14]

22. Kroenke K, Spitzer RL, Williams JB, et al. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. *General hospital psychiatry* 2010;32(4):345-59. doi: 10.1016/j.genhosppsych.2010.03.006 [published Online First: 2010/07/17]

23. Spitzer RL, Kroenke K, Williams JB, et al. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of internal medicine* 2006;166(10):1092-7. doi: 10.1001/archinte.166.10.1092 [published Online First: 2006/05/24]

24. Cohen S. Perceived stress in a probability sample of the United States. The social psychology of health. Thousand Oaks, CA, US: Sage Publications, Inc 1988:31-67.

25. Diener E, Wirtz D, Tov W, et al. New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings. *Social Indicators Research* 2010;97:143-56.

26. Lumley T, Diehr P, Emerson S, et al. The Importance of the Normality Assumption in Large Public Health Data Sets. *Annual Review of Public Health* 2002;23(1):151-69. doi: 10.1146/annurev.publhealth.23.100901.140546

27. Kocalevent RD, Hinz A, Brähler E. Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *General hospital psychiatry* 2013;35(5):551-5. doi: 10.1016/j.genhosppsych.2013.04.006 [published Online First: 2013/05/15]

28. Warttig SL, Forshaw MJ, South J, et al. New, normative, English-sample data for the Short Form Perceived Stress Scale (PSS-4). *Journal of health psychology* 2013;18(12):1617-28. doi: 10.1177/1359105313508346 [published Online First: 2013/10/25]

29. Löwe B, Decker O, Müller S, et al. Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Medical care* 2008;46(3):266-74. doi: 10.1097/MLR.0b013e318160d093 [published Online First: 2008/04/05]

30. Owen JE, Bantum EOC, Criswell K, et al. Representativeness of two sampling procedures for an internet intervention targeting cancer-related distress: a comparison of convenience and registry samples. *J Behav Med* 2014;37(4):630-41. doi: 10.1007/s10865-013-9509-6 [published Online First: 2013/05/04]

31. https://files.digital.nhs.uk/pdf/q/3/mental_health_and_wellbeing_in_england_full_report.pdf [accessed 03/05/20].

32. Hidaka BH. Depression as a disease of modernity: explanations for increasing prevalence. *Journal of affective disorders* 2012;140(3):205-14. doi: 10.1016/j.jad.2011.12.036 [published Online First: 2012/01/12]

33. https://www.marchnetwork.org/research [accessed 04/05/20].

34. Masi CM, Chen H-Y, Hawkley LC, et al. A meta-analysis of interventions to reduce loneliness. *Pers Soc Psychol Rev* 2011;15(3):219-66. doi: 10.1177/1088868310377394 [published Online First: 2010/08/17]

35. https://thepsychologist.bps.org.uk/we-will-have-live-risk-covid-19-psychology-has-much-say-about-risk [accessed 06/05/2020].

Supplementary Appendices

Appendix 1: Details of modifiable and non-modifiable explanatory factors

Appendix 2: Results from univariable regressions

Appendix 3: Multivariable regression models, excluding perceived risk of COVID-19

Appendix 4: Boxplots of outcome variables

Appendix 5: Means for depression, anxiety and stress with overall means weighted to mid-2019 UK population distribution

---

Appendix 1: Summary of modifiable and non-modifiable explanatory factors considered in the analysis

Table S1: Modifiable and non-modifiable 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		Health, social care ore relevant related support worker
		Teacher or childcare worker still travelling in to work

	Are you currently fulfilling any of the government's identified 'key worker' roles?	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		
Perceived loneliness[†]	On a scale of 1-10, how lonely have you felt over the past 2 weeks?	1 (Not at all lonely) - 10 (Extremely lonely)
Perceived risk of COVID-19	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)
Positive mood[‡]	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
	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
COVID-19 worry	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 (α=0.94).[25]

Appendix 2: Results from univariable regressions

Depression (PHQ-9)

Table S2: 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 S3: 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 S4: 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 S5: 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"

Anxiety (GAD-7)

Table S6: 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 S7: 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 S8: 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 S9: 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"

Stress (PSS-4)

Table S10: 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 S11: 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 3: Multivariable regression models, excluding perceived risk of COVID-19

Table S12: 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*	*p*
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 R^2=.56, p<.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 S13: 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*	*p*
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 R^2=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 S14: 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*	*p*
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 R^2=.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 S15: 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*	*p*
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 R^2=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 S16: 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*	*p*
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 R^2=.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 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
Overall[1]	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
Overall[1]	2617	**7.32**	**6.18**	**6.36**
Overall: Males and females[1]		**6.71**	**5.56**	**6.03**

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

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study Design	4	Present key elements of study design early in the paper	5-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	
		Case-control study—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7, Supplementary Appendx

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7 Supplementary
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study Size	10	Explain how the study size was arrived at	6 (n/a)
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	8 (NA)
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	10, 11, Supplemental
		(*e*) Describe any sensitivity analyses	7-8, Supplemental Appendix
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10, supplemental appendix
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	12-13, Supplementar

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-21, Supplemental
		(*b*) Report category boundaries when continuous variables were categorized	8, 10-20, Supplemental
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-21, Supplemental Appendix
Discussion			
Key Results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21-24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	21-24
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25-26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-040620.R2
Article Type:	Original research
Date Submitted by the Author:	20-Aug-2020
Complete List of Authors:	Jia, Ru; University of Nottingham Division of Primary Care Ayling, Kieran; University of Nottingham Division of Primary Care Chalder, Trudie; King's College London, PSYCHOLOGICAL MEDICINE Massey, Adam; University of Nottingham Division of Primary Care Broadbent, E; The University of Auckland Faculty of Medical and Health Sciences Coupland, Carol; University of Nottingham, Division of Primary Care Vedhara, Kavita; University of Nottingham, Division of Primary Care
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Epidemiology, Health services research, Public health
Keywords:	MENTAL HEALTH, PSYCHIATRY, PUBLIC HEALTH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

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

[1]Ru Jia MSc [Research Assistant],

[1]Kieran Ayling PhD [Senior Research Fellow],

[2]Trudie Chalder PhD [Professor of Cognitive Behavioural Psychotherapy],

[1]Adam Massey PhD [Honorary Research Associate],

[3]Elizabeth Broadbent PhD [Professor in Health Psychology],

[1]Carol Coupland PhD [Professor of Medical Statistics in Primary Care],

[1*]Kavita Vedhara PhD [Professor of Health Psychology]

[1]Division of Primary Care

University of Nottingham

University Park

Nottingham, NG7 2RD

[2]Department of Psychological Medicine,

Institute of Psychiatry, Psychology & Neuroscience,

King's College London,

16, De Crespigny Park,

London, SE5 8AF,

United Kingdom.

[3]Department of Psychological Medicine,

University of Auckland,

Private bag 92019, Auckland,

New Zealand.

* Author to whom all correspondence should be addressed: Professor Kavita Vedhara, Division of Primary Care, University of Nottingham, University Park, Nottingham, NG7 2RD, UK.
Kavita.vedhara@nottingham.ac.uk; Tel +44 115 8466931

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.covidstressstudy.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 (α=0.88), depression (α=0.92) and stress (α=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 large[26], 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%)	1,864890 (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 norms[27-29]. 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		Participants	Norms		Participants	Norms	
	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t	Mean (SD)	Mean (SD)	t
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 (p=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 (p=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 (p=0.051)	3.32 (3.8)	2.79 (3.2)	1.92 (p=0.056)	5.07 (3.0)	..	..
≥75	4.39 (5.8)	4.4 (3.9)	0.02 (p=0.99)	2.92 (4.4)	3.05 (3.4)	0.21 (p=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-9[27], GAD-7[29], PSS-4[28].

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

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

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

[†] Cut-offs for categories in line with published guidelines for PHQ-9[23] 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 R^2=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 R^2=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 R^2=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 R^2=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*	*p*
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 R^2=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 R^2=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 R^2=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*	*p*
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 R^2=.54, n=2494					
	Odds Ratio	**95% CI Lower**	**95% CI Upper**	***β***	***p***
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 R^2=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*	*p*
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 R^2=.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 health [33]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.

Funding

KA was supported by funding from the National Institute for Health Research School for Primary Care Research (NIHR SPCR). The views expressed are those of the author(s) and not necessarily those of the NIHR, the NHS or the Department of Health.

TC acknowledges the financial support of the Department of Health via the National Institute for Health Research (NIHR) Specialist Biomedical Research Centre for Mental Health award to the South London and Maudsley NHS Foundation Trust (SLaM) and the Institute of Psychiatry at King's College London. The views

expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care. No other funding supported the work described in this manuscript.

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

References

1. Holmes EA, O'Connor RC, Perry VH, et al. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The lancet Psychiatry* 2020;7(6):547-60. doi: 10.1016/s2215-0366(20)30168-1 [published Online First: 2020/04/19]

2. Candan SA, Elibol N, Abdullahi A. Consideration of prevention and management of long-term consequences of post-acute respiratory distress syndrome in patients with COVID-19. *Physiotherapy Theory and Practice* 2020;36(6):663-68. doi: 10.1080/09593985.2020.1766181

3. Liu S, Yang L, Zhang C, et al. Online mental health services in China during the COVID-19 outbreak. *The lancet Psychiatry* 2020;7(4):e17-e18. doi: 10.1016/s2215-0366(20)30077-8 [published Online First: 2020/02/23]

4. Tian F, Li H, Tian S, et al. Psychological symptoms of ordinary Chinese citizens based on SCL-90 during the level I emergency response to COVID-19. *Psychiatry research* 2020;288:112992. doi: 10.1016/j.psychres.2020.112992 [published Online First: 2020/04/18]

5. Jeong H, Yim HW, Song Y-J, et al. Mental health status of people isolated due to Middle East Respiratory Syndrome. *Epidemiol Health* 2016;38:e2016048-e48. doi: 10.4178/epih.e2016048

6. Chan SM, Chiu FK, Lam CW, et al. Elderly suicide and the 2003 SARS epidemic in Hong Kong. *International journal of geriatric psychiatry* 2006;21(2):113-8. doi: 10.1002/gps.1432 [published Online First: 2006/01/18]

7. Williams SN, Armitage CJ, Tampe T, et al. Public perceptions and experiences of social distancing and social isolation during the COVID-19 pandemic: a UK-based focus group study. *BMJ Open* 2020;10(7):e039334. doi: 10.1136/bmjopen-2020-039334

8. https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/coronaviruscovid19relateddeathsbyoccupationenglandandwales/deathsregistereduptoandincluding20april2020 [accessed 11/05/20].

9. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study; [published correction appears in Lancet. 2020 Mar 28;395(10229):1038]. . *The Lancet* 2020;395(10229):p1054-62.

10. Khunti K, Singh AK, Pareek M, et al. Is ethnicity linked to incidence or outcomes of covid-19? *BMJ* 2020;369:m1548. doi: 10.1136/bmj.m1548

11. Folkman S. Positive psychological states and coping with severe stress. *Social science & medicine (1982)* 1997;45(8):1207-21. doi: 10.1016/s0277-9536(97)00040-3 [published Online First: 1997/09/25]

12. Bults M, Beaujean DJ, de Zwart O, et al. Perceived risk, anxiety, and behavioural responses of the general public during the early phase of the Influenza A (H1N1) pandemic in the Netherlands: results of three consecutive online surveys. *BMC public health* 2011;11:2. doi: 10.1186/1471-2458-11-2 [published Online First: 2011/01/05]

13. Salkovskis PM, Rimes KA, Warwick HM, et al. The Health Anxiety Inventory: development and validation of scales for the measurement of health anxiety and hypochondriasis. *Psychological medicine* 2002;32(5):843-53. doi: 10.1017/s0033291702005822 [published Online First: 2002/08/13]

14. Gao J, Zheng P, Jia Y, et al. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS One* 2020;15(4):e0231924-e24. doi: 10.1371/journal.pone.0231924

15. Wang J, Mann F, Lloyd-Evans B, et al. Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC psychiatry* 2018;18(1):156. doi: 10.1186/s12888-018-1736-5 [published Online First: 2018/05/31]

16. Leigh-Hunt N, Bagguley D, Bash K, et al. An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public health* 2017;152:157-71. doi: 10.1016/j.puhe.2017.07.035 [published Online First: 2017/09/16]

17. Pressman SD, Jenkins BN, Moskowitz JT. Positive Affect and Health: What Do We Know and Where Next Should We Go? *Annual review of psychology* 2019;70:627-50. doi: 10.1146/annurev-psych-010418-102955 [published Online First: 2018/09/28]

18. Larsen JT, Hershfield HE, Stastny BJ, et al. On the relationship between positive and negative affect: Their correlation and their co-occurrence. *Emotion (Washington, DC)* 2017;17(2):323-36. doi: 10.1037/emo0000231 [published Online First: 2016/10/28]

19. Dejonckheere E, Mestdagh M, Verdonck S, et al. The relation between positive and negative affect becomes more negative in response to personally relevant events. *Emotion (Washington, DC)* 2019 doi: 10.1037/emo0000697 [published Online First: 2019/11/08]

20. Schotanus-Dijkstra M, Ten Have M, Lamers SMA, et al. The longitudinal relationship between flourishing mental health and incident mood, anxiety and substance use disorders. *Eur J Public Health* 2017;27(3):563-68. doi: 10.1093/eurpub/ckw202

21. Schotanus-Dijkstra M, Keyes CLM, de Graaf R, et al. Recovery from mood and anxiety disorders: The influence of positive mental health. *Journal of affective disorders* 2019;252:107-13. doi: 10.1016/j.jad.2019.04.051 [published Online First: 2019/04/14]

22. Kroenke K, Spitzer RL, Williams JB, et al. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. *General hospital psychiatry* 2010;32(4):345-59. doi: 10.1016/j.genhosppsych.2010.03.006 [published Online First: 2010/07/17]

23. Spitzer RL, Kroenke K, Williams JB, et al. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of internal medicine* 2006;166(10):1092-7. doi: 10.1001/archinte.166.10.1092 [published Online First: 2006/05/24]

24. Cohen S. Perceived stress in a probability sample of the United States. The social psychology of health. Thousand Oaks, CA, US: Sage Publications, Inc 1988:31-67.

25. Diener E, Wirtz D, Tov W, et al. New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings. *Social Indicators Research* 2010;97:143-56.

26. Lumley T, Diehr P, Emerson S, et al. The Importance of the Normality Assumption in Large Public Health Data Sets. *Annual Review of Public Health* 2002;23(1):151-69. doi: 10.1146/annurev.publhealth.23.100901.140546

27. Kocalevent RD, Hinz A, Brähler E. Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *General hospital psychiatry* 2013;35(5):551-5. doi: 10.1016/j.genhosppsych.2013.04.006 [published Online First: 2013/05/15]

28. Warttig SL, Forshaw MJ, South J, et al. New, normative, English-sample data for the Short Form Perceived Stress Scale (PSS-4). *Journal of health psychology* 2013;18(12):1617-28. doi: 10.1177/1359105313508346 [published Online First: 2013/10/25]

29. Löwe B, Decker O, Müller S, et al. Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Medical care* 2008;46(3):266-74. doi: 10.1097/MLR.0b013e318160d093 [published Online First: 2008/04/05]

30. Owen JE, Bantum EOC, Criswell K, et al. Representativeness of two sampling procedures for an internet intervention targeting cancer-related distress: a comparison of convenience and registry samples. *J Behav Med* 2014;37(4):630-41. doi: 10.1007/s10865-013-9509-6 [published Online First: 2013/05/04]

31. https://files.digital.nhs.uk/pdf/q/3/mental_health_and_wellbeing_in_england_full_report.pdf [accessed 03/05/20].

32. Hidaka BH. Depression as a disease of modernity: explanations for increasing prevalence. *Journal of affective disorders* 2012;140(3):205-14. doi: 10.1016/j.jad.2011.12.036 [published Online First: 2012/01/12]

33. Chabaud F, Benradia I, Bouet R, et al. Facteurs de risque sociodémographiques et troubles mentaux : modèle global et spécificités locales, d'après les résultats de l'enquête « santé mentale en population générale » dans 18 sites internationaux. *L'Encéphale* 2017;43(6):540-57. doi: https://doi.org/10.1016/j.encep.2016.04.009

34. https://www.marchnetwork.org/research [accessed 04/05/20].

35. Masi CM, Chen H-Y, Hawkley LC, et al. A meta-analysis of interventions to reduce loneliness. *Pers Soc Psychol Rev* 2011;15(3):219-66. doi: 10.1177/1088868310377394 [published Online First: 2010/08/17]

36. https://thepsychologist.bps.org.uk/we-will-have-live-risk-covid-19-psychology-has-much-say-about-risk [accessed 06/05/2020].

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*	*p*
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 R^2=.56, *p*<.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*	*p*
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 R^2=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*	*p*
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 R^2=.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*	*p*
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 R^2=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*	*p*
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 R^2=.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		
Perceived loneliness[†]	On a scale of 1-10, how lonely have you felt over the past 2 weeks?	1 (Not at all lonely) - 10 (Extremely lonely)
Perceived risk of COVID-19	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)
Positive mood[‡]	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
	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
COVID-19 worry	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 (α=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
Overall[1]	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
Overall[1]	2617	**7.32**	**6.18**	**6.36**
Overall: Males and females[1]		**6.71**	**5.56**	**6.03**

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

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study Design	4	Present key elements of study design early in the paper	5-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	
		Case-control study—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7, Supplementary Appendx

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7 Supplementary
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study Size	10	Explain how the study size was arrived at	6 (n/a)
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	8 (NA)
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	10, 11, Supplemental
		(*e*) Describe any sensitivity analyses	7-8, Supplemental Appendix
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10, supplemental appendix
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	12-13, Supplementar

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-21, Supplemental
		(*b*) Report category boundaries when continuous variables were categorized	8, 10-20, Supplemental
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-21, Supplemental Appendix
Discussion			
Key Results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21-24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	21-24
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25-26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.