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Effects of COVID-19-related worry and rumination on mental health and loneliness during the pandemic: longitudinal analyses of adults in the UK COVID-19 mental health & wellbeing study

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ABSTRACT

Background: The lasting effects of the coronavirus disease 2019 pandemic are likely to be significant.
Aims: This study tracked worry and rumination levels during the pandemic and investigated whether periods with higher COVID-related worry and rumination were associated with more negative mental health and loneliness.
Methods: A quota survey design and a sampling frame that permitted recruitment of a national sample were employed. Findings for waves 1 (March 2020) to 6 (November 2020) are reported ($N = 1943$).
Results: Covid-related worry and rumination levels were highest at the beginning of the first lockdown, then declined but increased when the UK returned to lockdown. Worry levels were higher than rumination levels throughout. High levels of COVID-related worry and rumination were associated with a five- and ten-fold increase in clinically meaningful rates of depression and anxiety (respectively) together with lower well-being and higher loneliness. The effects of COVID-related worry on depression and anxiety levels were most marked and clinically meaningful in individuals living with a pre-existing mental health condition.
Conclusions: Psychological interventions should include components that specifically target COVID-related worry and rumination. Individuals with pre-existing mental health conditions should be prioritised as we emerge from the current pandemic and in any future public health crises.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic is the greatest international public health emergency the world has faced for a century. It has impacted how we work, educate, parent, socialise, shop, communicate and travel (O'Connor et al., 2020a). In addition to the large numbers of COVID-19 cases and fatalities, it has led to national 'lockdowns' that involved physical distancing, restricted movement, quarantine, high levels of isolation, forced remote working, home-schooling, furlough, and bereavements at scale. Moreover, frontline workers have been exposed to alarming levels of stress (Al-Ghunaim et al., 2021; British Medical Association, 2020; Greenberg et al., 2020). The lasting effects of the COVID-19 pandemic are likely to be significant, particularly in regard to mental health and wellbeing. Recent reports have shown the negative effects of the early stages of the pandemic on mental health in China, where one study demonstrated that 28.8% of participants reported moderate or

severe anxiety and 16.5% reported moderate or severe levels of depression (Wang et al., 2020). In the United Kingdom, a large-scale longitudinal probability sample survey found that the prevalence of clinically significant levels of mental distress increased from 18.9% in 2018–19 to 27.3% in April 2020, one month into the UK lockdown (Pierce et al., 2020). In another UK study using a national sample, we found that the mental health and well-being of the UK adult population were negatively affected in the initial phase of the COVID-19 pandemic (O'Connor et al., 2021). Similarly, a UK community cohort study echoed these findings reporting that levels of depression and anxiety exceeded population norms early in the pandemic (Jia et al., 2020). Comparable findings have been reported in several different countries, including Denmark (Sønderskov et al., 2020) and the USA (Fitzpatrick et al., 2020). However, it is worth noting that the COVID-19 pandemic has also led to positive social and behavioural changes (e.g., in terms of hand

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hygiene and physical exercise), new ways of working, and increases in compassion and community resilience (O'Connor et al., 2020a; Williams et al., 2021).

It is also clear from the converging evidence that the COVID-19 pandemic is disproportionately impacting different groups (Fancourt et al., 2021; Holmes et al., 2020; O'Connor et al., 2020a; Pierce et al., 2020; Vindegaard & Benros, 2020). Individuals from younger age groups, women, people with lower income and educational attainment, members of ethnic minority groups, those with existing physical and mental health conditions are at greater risk of psychological morbidity (e.g., Fancourt et al., 2021; Özdin & Bayrak Özdin, 2020; Smith et al., 2020). However, in addition to sociodemographic and mental/physical health issues, there are likely to be additional factors that influence individuals' psychological responses to the pandemic. One potential factor is perseverative cognition – or worry and rumination. Perseverative cognition is an umbrella term used to describe repetitive, intrusive, and negative thought processes which are associated with the cognitive representation of past stressful events (rumination) or feared future events (worry) (Brosschot et al., 2006). It includes both rumination, which is associated with depression, and worry which is associated with anxiety disorders, particularly Generalised Anxiety Disorder (Clancy et al., 2016). Perseverative cognition is related to poor physical health, increased susceptibility to stress-related ill-health, as well as negative health behaviours (Clancy et al., 2016, 2020; Ottaviani et al., 2016).

In this paper, we report on the first six waves of the UK COVID-19 Mental Health and Wellbeing Study (covering March 2020 to November 2020), a longitudinal, national survey. It aimed to assess the immediate and longer-term impact of the COVID-19 pandemic on mental health, wellbeing and loneliness, including the nationwide lockdown enforced across the UK on 23rd March 2020. O'Connor et al. (2021) reported the initial results on the trajectory of mental health and wellbeing during the first 6 weeks of the UK lockdown. The current study tracked worry and rumination (perseverative cognition) levels during the first 9 months of the pandemic and investigated whether COVID-related worry and rumination levels were associated with more negative mental health outcomes and higher levels of loneliness. It also investigated key potential moderators of these relationships, in particular, living with a physical or mental health long-term condition.

Methods

Participant recruitment was conducted by Taylor McKenzie, a social research company. A non-probability sample of adults (aged 18 years or older) was recruited from across the UK for the UK COVID-19 Mental Health & Wellbeing study (UK COVID-MH), with a longitudinal study design. The UK COVID-MH has been detailed previously (O'Connor et al., 2021) and was preregistered at AsPredicted.org (#41910).

Between 31st March and 4th November 2020, members of an existing online UK panel (Panelbase.net) were invited by email to take part in an online survey on health and wellbeing. At wave 1, 7471 panel members were invited to take part and 3077 were included in the final sample (target sample was $n = 3,000$). A quota sampling methodology was employed, with quotas based on age (18–24 years: 12%; 25–34: 17%; 35–44: 18%; 45–54: 18%; 55–64: 15%; ≥65: 20%), gender (women: 51%; men: 49%), socioeconomic grouping (SEG; AB:27%; C1: 28%; C2: 20%; DE: 25%, based on occupation, where A, B and C1 are higher and categories C2, D, E are lower) and region of the UK (12 regions). The panel has approximately 300,000 registered adult members and of those invited, 4394 did not take part in the survey. The majority were screened out as a particular quota was full ($n = 3527$) and the remainder dropped out ($n = 867$). 90% of the 4394 panel members who were invited to participate but did not take part in the survey provided details of their age and gender: 65.6% identified as female and 34.3% as male. The age distribution was as follows: 18–29 years = 19%, 30–59 years = 62.9%, and 60+ years =18.1%.

As outlined above, a total of 3077 adults completed the survey in wave 1. Findings for waves 1 (31 March to 9 April 2020), to 6 (1st October – 4th November 2020) are reported in the current paper. At wave 2, 89% of participants ($n = 2742$) completed the survey, 85% ($n = 2604$) completed wave 3, 77.5% ($n = 2384$) completed wave 4, 69.7%
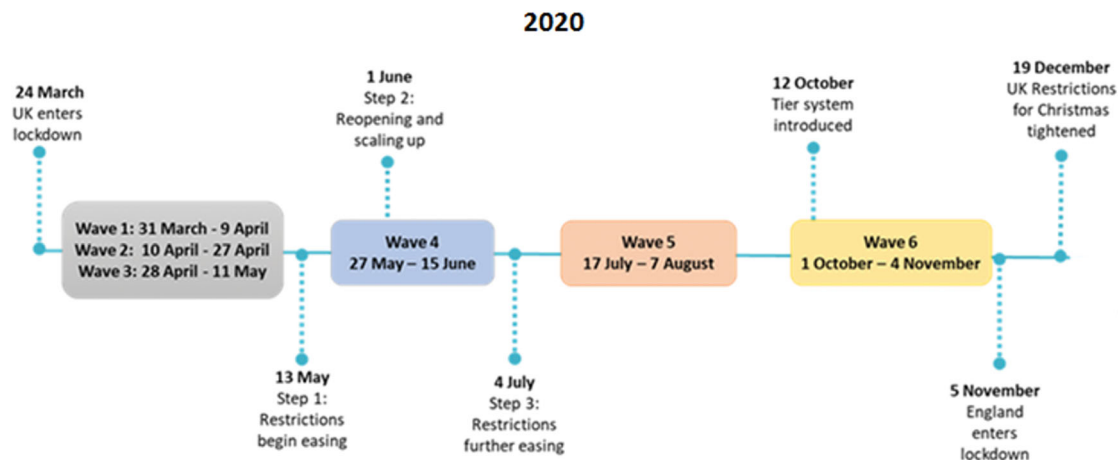

Figure 1. Overview of the waves of the UK COVID-19 Mental Health & Wellbeing study and key events during the COVID-19 pandemic in the UK in 2020.

($n = 2144$) completed wave 5 and 74.2% ($n = 2283$) completed wave 6. 1943 (63.1%) participants completed all six waves of the study. Figure 1 illustrates the changes in public health restrictions in the UK occurring during each wave. The first three waves occurred within the first 6 weeks of the UK lockdown, and the subsequent three waves were roughly every 2–3 months, with the interval between waves increasing over time. Waves 4 (May-June 2020) and 5 (July/August) coincided with the easing of the restrictions while wave 6 (October/November 2020) coincided with the increasing of restrictions again across the UK with cases of COVID-19 on the rise.

The survey included questions on a wide range of psychological and social measures along with questions about COVID-19. In this paper, we test whether COVID-related rumination and worry (perseverative cognition) predict levels of depression, anxiety, mental well-being and loneliness and whether living with an existing physical or mental health condition moderates any emergent effects. Participants were informed that they would have the opportunity to participate in a minimum of six waves of the survey that would track the health and wellbeing of the UK during the current COVID-19 pandemic.

Ethical approval

The study was approved by the University of Glasgow's Medical, Veterinary & Life Sciences Ethics Committee (approval number: 200190146) and participants consented for their data to be used in the research. Participants received £1.50 for the completion of each survey and were entered into prize draws.

Measures

COVID-related rumination and worry were assessed using single-item measures rated on a scale of 1 (never) to 7 (very often) informed by previous research (e.g., Clancy et al., 2016; 2020). Worry was first defined as: "Negative, repetitive thoughts about future events which have the potential to be stressful or upsetting. These worrisome thoughts are usually distressing, can be difficult to control, and can lead to a spiral of different worries." Participants were then asked to indicate over the past two weeks how often they worried or focused on COVID-19-related things that may occur or happen in the future. Rumination was defined as: "Negative, repetitive thoughts about upsetting emotions or events which have happened in the past (including today). These ruminative thoughts are usually distressing, can be difficult to control, and can lead to a spiral of different ruminations." Participants were asked again to indicate over the past two weeks how often they ruminated over COVID-19-related things that have happened or upset them in the past.

Depressive symptoms were assessed via the nine-item Patient Health Questionnaire (PHQ-9; Löwe et al., 2004; Kroenke & Spitzer, 2002; Kroenke et al., 2001). The 7-item Generalized Anxiety Disorder (GAD-7; Spitzer et al., 2006)

tool was used to assess symptoms of generalised anxiety disorder. Both measures ask how often symptoms have been bothering the respondents in the past 2 weeks on a scale of 0 (not at all) to 3 (nearly every day). Cronbach's alpha for the scales in the current sample ranged from .90 to .93, and .92 to .94, respectively. Scores range from 0 to 27 on the PHQ-9 and 0–21 on the GAD-7, with higher scores indicating greater levels of depression and anxiety. Scores of ≥ 10 on both measures are thought to indicate clinically significant cut-offs as indicators of moderate levels of depression and anxiety (Kroenke & Spitzer, 2002; Spitzer et al., 2006).

Mental wellbeing was assessed via the 7-item Short Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS; Fat et al., 2017). Participants were asked to respond about their experiences over the last 2 weeks on a 1 (none of the time) to 5 (all the time) scale. Cronbach's alphas for the scale in the current sample ranged from .89 to .92. Scores range from 7 to 35 with a higher score indicating better mental wellbeing. A score of 19.3 is thought to indicate low levels of mental well-being and is used as a clinically significant cut-off (Fat et al., 2017). Loneliness was measured using the UCLA 3-item loneliness scale (Hughes et al., 2004). Participants were asked to respond about their experiences over the last 2 weeks on a three-point scale (hardly ever, some of the time, often). Scores ranged from 3 to 9 where a higher score indicates greater loneliness. Cronbach's alphas for the scale in the current sample ranged from .88 to .90. To our knowledge, there are no published cut-offs indicative of clinical significance for this measure, we, therefore, separated scores based on a cut-off of 7 or more as indicative of high loneliness. This would indicate that individuals rate their frequency of experiencing at least one of the items 'often' with the remaining two items experienced 'some of the time'.

To assess health status, participants were first asked if they had any long-standing physical or mental health impairment, illness, or disability. Participants were then asked to select their mental or physical health impairment. They were also asked to indicate whether they had any mental health conditions, neuro-divergent disorders, or alcohol/drug problems.

Statistical analyses

Analyses were conducted in Stata 16 and multilevel models were conducted in HLM 7 (Raudenbush et al., 2011). Analyses were conducted using complete case analyses, where only participants completing all six waves were included in the analysis. Multiple imputations were also carried out and 10 imputed datasets were created; analyses were then conducted on a randomly selected dataset and the results of the imputed and complete cases were compared. Multivariate analysis of variance (MANOVA) was used to investigate changes in COVID-related worry and rumination across the 6 waves.

Hierarchical linear modelling was used to assess the relationship between COVID-related worry and rumination and mental health (depression, anxiety, and wellbeing) and

loneliness scores. The data were considered to have a two-level hierarchical structure. Level 1 variables (COVID-related worry and rumination, levels of depression, anxiety, mental wellbeing, and loneliness at each wave) were group mean centred. Level 2 variables (gender (female, male), age (under 30, over 30), physical and mental health status (any mental health conditions reported: no/yes; any physical health conditions reported: no/yes), socioeconomic group (SEG; assessed via The National Readership Survey social grade): high $(A + B + C1)$ vs. low $(C2 + D + E)$) were uncentred as they were dichotomous variables. The level 1 variables were modelled as random as we assumed that each of the within-person variables would vary from wave to wave. The level 2 variables were assumed to be fixed. For all the models tested here, an unrestricted level 1 variance-covariance structure was assumed. The main analyses were conducted in two blocks. First, we examined whether COVID-related worry and rumination (over the past 2 weeks) were associated with each of the mental health and wellbeing outcomes (over the past 2 weeks) across the 6 waves. In these analyses, gender, age and SEG, mental and physical health conditions were entered as covariates. The wave was also entered as a control variable in all analyses. Second, we explored whether the effects of COVID-related worry and rumination on mental health and loneliness were moderated by mental and physical health status. The main HLM models tested in the current paper were informed *a priori* by the emerging evidence, outlined in the Introduction, and by published findings from the current sample in the early phrase of the pandemic (O'Connor et al., 2021) that show that the COVID-19 pandemic has disproportionately impacted on different groups (e.g., individuals living with mental health conditions or living in more deprived areas, younger people, etc.). However, in addition, using likelihood-ratio tests in HLM, we compared model fit using deviance statistics to explore whether the inclusion of sociodemographic and moderating variables significantly contributed to the explained variance for each outcome. The chi-square statistic was statistically significant in each case $(p < 0.001)$. In addition, for all HLM analyses, we followed the recommendations put forward by Simmons et al. (2011) in terms of transparency regarding the treatment of covariates. These authors have suggested that "if an analysis includes a covariate, authors must report the statistical results of the analysis without the covariate" (p.1363). Therefore, to strengthen the robustness of the current results, we present the main models first without any covariates and then with the covariates.

The general form of the full HLM model was:

$$DEPRESSION = \beta_{00} + \beta_{02}*PHYSICALHEALTH + \beta_{02}*GENDER + \beta_{03}*SEG + \beta_{04}*MENTALHEALTH + \beta_{05}*AGE + \beta_{10}*WAVE + \beta_{20}*WORRY + \beta_{21}*PHYSICALHEAHLTH*WORRY + \beta_{22}*GENDER*WORRY + \beta_{23}*SEG*WORRY + \beta_{24}*MENTAL HEALTH*WORRY + \beta_{25}*AGE*WORRY + r_0 + r_1*WAVE + r_2 * WORRY + e$$

Results

Worry, rumination, mental health and loneliness across the six waves

COVID-related worry and rumination reduced over the 6 waves, along with depression, anxiety, and loneliness while wellbeing increased across the 6 waves (Table 1 and Figure 2). Specifically, results of the MANOVA showed that COVID-related worry was highest at wave 1, but reduced significantly across the waves and was at its lowest at wave 5, $F(5, 11664) = 60.55$, $p < .001$, wave 5 was not significantly different to wave 6. COVID-related rumination levels were highest at waves 1 and 2, these reduced significantly across the waves and again were lowest at wave 5, $F(5, 11664) = 17.88$, $p = .001$, again, wave 5 was not significantly different to wave 6. Pairwise comparisons for each wave demonstrated that worry was significantly higher than rumination at all six waves $(p < .001)$. For the mental health outcomes, anxiety was highest at wave 1 and reduced significantly across the waves, $F(5, 11664) = 3.66$, $p = .002$, mental wellbeing was lowest at wave 1 and increased across the waves, $F(5, 11664) = 4.49$, $p < .001$. Depression and loneliness were stable across the waves, $F(5, 11664) = 1.16$, $p = .325$ and $F(5, 11664) = .882$, $p = .492$, respectively.

There were significant main effects of gender, age, SEG, and both mental and physical health conditions on COVID-related worry and rumination as well as for depression, anxiety, and wellbeing. Women, younger individuals (under thirty years old), those from a low SEG and individuals reporting at least one mental or physical health condition reported greater worry, rumination, depression and anxiety and lower wellbeing $(p < .001)$. Younger individuals, those from a low SEG and with at least one mental health condition also reported greater loneliness. Mean scores for depression, anxiety, wellbeing, and loneliness along with

Table 1. Mean perseverative cognition and mental health outcomes across the six study waves (31 March 2020 to 4th November 2020).

	Wave 1 31 Mar-9 Apr	Wave 2 10 Apr-27 Apr	Wave 3 28 Apr-11 May	Wave 4 27 May-15 Jun	Wave 5 17 Jul-7 Aug	Wave 6 1 Oct-4 Nov
Mean (SD)						
Worry[a]	3.64 (1.85)	3.55 (1.77)	3.32 (1.77)	3.01 (1.72)	2.86 (1.73)	3.08 (1.77)
Rumination[b]	2.87 (1.83)	2.89 (1.79)	2.75 (1.78)	2.56 (1.70)	2.48 (1.68)	2.64 (1.76)
Depression	5.6 (6.25)	5.49 (6.11)	5.54 (6.28)	5.25 (6.04)	5.24 (6.23)	5.38 (6.32)
Anxiety	4.9 (5.21)	4.71 (5.18)	4.55 (5.24)	4.37 (5.20)	4.28 (5.55)	4.42 (5.22)
Wellbeing	22.78 (6.13)	23.01 (6.23)	23.15 (6.23)	23.54 (6.38)	23.53 (6.45)	23.34 (6.41)
Loneliness	5.11 (1.92)	5.10 (1.92)	5.08 (1.92)	5.06 (1.94)	5.03 (1.93)	5.01 (1.95)

[a]COVID-related worry over the past 2 weeks; [b]COVID-related rumination over the past 2 weeks. $N = 1943$ across all six waves.
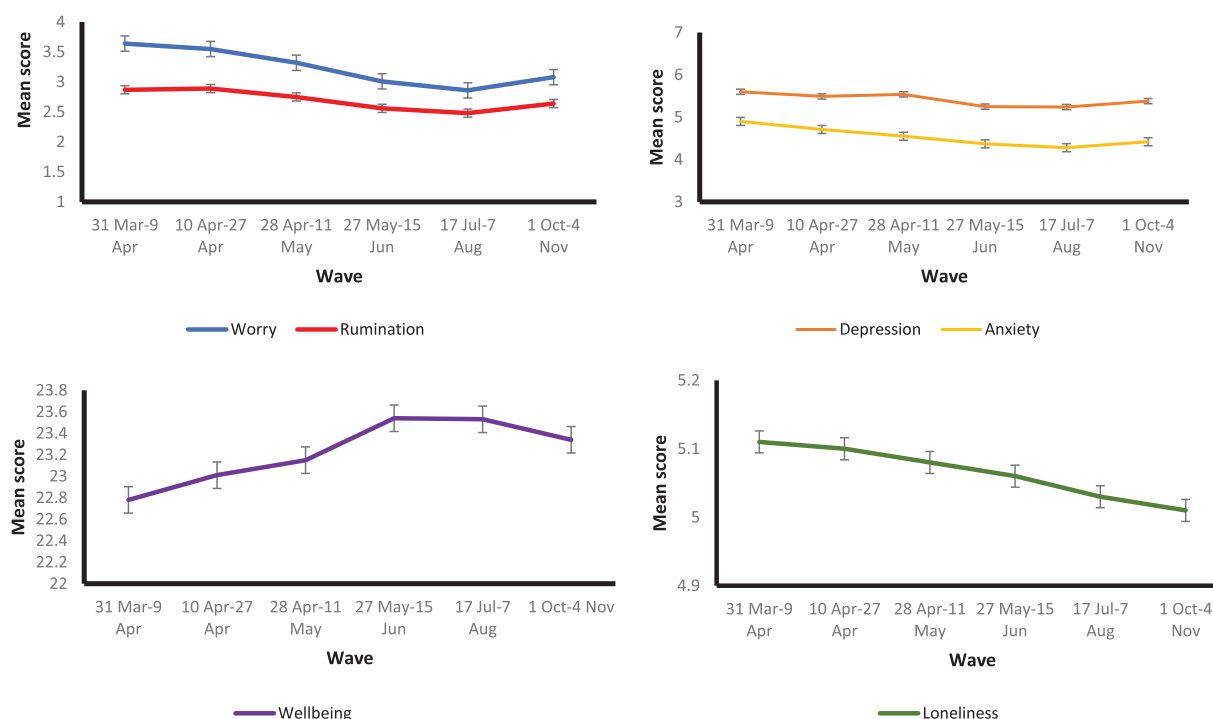
Figure 2. Mean COVID-related worry and rumination, mental health, and loneliness across the six waves (error bars represent standard errors).

COVID-related worry and rumination are reported by participant characteristic in Supplementary Table 1.

Are COVID-related worry and/or rumination levels associated with mental health and loneliness outcomes across the six waves?

The results of the hierarchical linear models found that there were significant positive associations between COVID-related worry and depression (Table 2a; unadjusted, $\beta = .55$, $p < .001$; adjusted, $\beta = 0.35$, $p < .001$), worry and anxiety (unadjusted, $\beta = .34$, $p < .001$; adjusted, $\beta = .39$, $p < .001$) worry and loneliness (unadjusted, $\beta = .05$, $p < .001$; adjusted, $\beta = .05$, $p < .001$) and a negative association between COVID-related worry and wellbeing (unadjusted, $\beta = -.51$, $p < .001$; adjusted, $\beta = -.32$, $p < .001$). In particular, the results showed that weeks with higher levels of COVID-related worry were associated with higher levels of depression and anxiety, loneliness and lower wellbeing across the 6 waves. Similarly, there were significant associations between COVID-related rumination and depression (unadjusted, $\beta = .55$, $p < .001$; adjusted, $\beta = .36$, $p < .001$), anxiety (unadjusted, $\beta = .58$, $p < .001$; adjusted, $\beta = .35$, $p < .001$), rumination and loneliness (unadjusted, $\beta = .07$, $p < .001$; adjusted, $\beta = .07$, $p < .001$) and a negative association between COVID-related rumination and wellbeing (unadjusted, $\beta = -.50$, $p < .001$; adjusted, $\beta = -.29$, $p < .001$).

Are the effects of COVID-related worry and rumination moderated by current mental or physical health status?

Mental health status was found to moderate the relationship between worry and depression ($\beta = .35$, $p < .001$; Table 2b). This interaction was decomposed using simple slopes:

although worry was positively associated with depression in individuals with ($\beta = 1.30$, $p < .001$), and without pre-existing mental health conditions ($\beta = 0.87$, $p < .001$) the impact of COVID-related worry was greatest in individuals living with pre-existing mental health conditions (see Supplementary Figure 1).

Mental health status moderated the relationship between worry and anxiety ($\beta = .29$, $p < .001$). Simple slopes analyses showed that although worry was positively associated with anxiety in individuals with ($\beta = 1.30$, $p < .001$), and without pre-existing mental health conditions ($\beta = 0.90$, $p < .001$), the effects of COVID-related worry on anxiety levels were greatest in individuals living with pre-existing mental health conditions (see Supplementary Figure 1).

Physical health status was found to moderate the relationship between worry and wellbeing ($\beta = .19$, $p = .008$). Simple slopes (Supplementary Figure 1) analyses showed that although worry was negatively associated with wellbeing in individuals with ($\beta = -0.41$, $p < .001$), and without pre-existing physical health conditions ($\beta = -0.27$, $p < .001$), the lowest levels of wellbeing were reported in individuals living with pre-existing physical health conditions during weeks with the highest worry levels.

Comparison with imputed dataset

There were some differences in the results produced by the randomly selected imputed dataset. In the imputed dataset, there was a significant relationship between depression and wave ($\beta = .06$, $p < .001$) and a significant moderating effect of mental health status on the relationship between worry and wellbeing ($\beta = -0.17$, $p = .002$). Otherwise, the results were very similar to the main analyses reported above.

Table 2a. Effects of COVID-related worry and rumination on depression, anxiety, wellbeing and loneliness across the six waves.

		Unadjusted					Adjusted for covariates			
		Coeff	SE	d.f.	p value		Coeff	SE	d.f.	p value
Depression										
Intercept	β_{00}	5.42	0.125	1942	<0.001	β_{00}	8.899	0.719	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−1.359	0.224	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.358	0.218	1937	0.102
Age	β_{03}	–	–	–	–	β_{03}	−1.993	0.322	1937	<0.001
Mental health status	β_{04}	–	–	–	–	β_{04}	5.459	0.218	1937	<0.001
Physical health status	β_{05}	–	–	–	–	β_{05}	0.591	0.234	1937	0.012
Level 1 slope										
Worry – depression	β_{10}	0.554	0.034	1942	<0.001	β_{10}	0.355	0.036	1942	<0.001
Level 1 slope										
Rumination – depression	β_{20}	0.555	0.036	1942	<0.001	β_{20}	0.364	0.037	1942	<0.001
Level 1 slope										
Wave – depression	β_{30}	−0.060	0.020	1942	0.003	β_{30}	0.020	0.019	1942	0.270
Anxiety										
Intercept	β_{00}	4.540	0.106	1942	<0.001	β_{00}	8.140	0.585	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−1.416	0.187	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.060	0.185	1937	0.744
Age	β_{03}	–	–	–	–	β_{03}	−1.528	0.266	1937	<0.001
Mental health status	β_{04}	–	–	–	–	β_{04}	4.531	0.250	1937	<0.001
Physical health status	β_{05}	–	–	–	–	β_{05}	0.319	0.200	1937	0.110
Level 1 slope										
Worry – anxiety	β_{10}	0.342	0.183	1937	<0.001	β_{10}	0.398	0.029	1942	<0.001
Level 1 slope										
Rumination – anxiety	β_{20}	0.584	0.028	1937	<0.001	β_{20}	0.351	0.028	1942	<0.001
Level 1 slope										
Wave – anxiety	β_{30}	−0.110	0.016	1942	<0.001	β_{30}	−0.016	0.014	1942	0.263
Wellbeing										
Intercept	β_{00}	23.221	0.127	1942	<0.001	β_{00}	19.941	0.706	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	0.552	0.243	1937	0.024
SEG	β_{02}	–	–	–	–	β_{02}	−0.323	0.237	1937	0.174
Age	β_{03}	–	–	–	–	β_{03}	2.060	0.318	1937	<0.001
Mental health status	β_{04}	–	–	–	–	β_{04}	−4.878	0.264	1937	<0.001
Physical health status	β_{05}	–	–	–	–	β_{05}	0.585	0.245	1937	0.017
Level 1 slope										
Worry – wellbeing	β_{10}	−0.507	0.033	1942	<0.001	β_{10}	−0.321	0.034	1942	<0.001
Level 1 slope										
Rumination – wellbeing	β_{20}	−0.499	0.034	1942	<0.001	β_{20}	−0.292	0.034	1942	<0.001
Level 1 slope										
Wave – wellbeing	β_{30}	0.137	0.019	1942	<0.001	β_{30}	0.064	0.019	1942	<0.001
Loneliness										
Intercept	β_{00}	5.064	0.039	1942	<0.001	β_{00}	6.169	0.218	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−0.456	0.075	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.133	0.075	1937	0.076
Age	β_{03}	–	–	–	–	β_{03}	−0.496	0.097	1937	<0.001
Mental health status	β_{04}	–	–	–	–	β_{04}	1.201	0.086	1937	<0.001
Physical health status	β_{05}	–	–	–	–	β_{05}	−0.064	0.080	1937	0.427
Level 1 slope										
Worry – loneliness	β_{10}	0.051	0.010	1942	<0.001	β_{10}	0.052	0.010	1942	<0.001
Level 1 slope										
Rumination – loneliness	β_{20}	0.066	0.010	1942	<0.001	β_{20}	0.067	0.011	1942	<0.001
Level 1 slope										
Wave – loneliness	β_{30}	−0.009	0.006	1942	0.107	β_{30}	−0.009	0.006	1942	0.113

Clinically meaningful effects

Depression, anxiety, and wellbeing scores were converted into a binary categorization based on previously published clinically meaningful cut-offs (scores of 10+ on the PHQ and GAD indicate moderate or severe levels of depression and anxiety; scores of 19.3 or less on the SWEMWBS indicate low wellbeing). As outlined earlier, high levels of loneliness were based on a cut-off of 7 or more. A median split was carried out on worry and rumination to separate participants into low vs. high worry/rumination. We then looked at the proportion of participants with high and low worry and rumination reporting clinically meaningful levels of depression, anxiety, well-being, and high loneliness (see Figure 3 and Supplementary Table 2).

On average across the six waves, just under 22% (n = 423) of the overall sample reported depression scores of 10+, 16% (n = 320) reported anxiety scores of 10+, both above the clinically meaningful threshold, 26% (n = 513) reported low mental wellbeing, and 19.8% (n = 385) reported high loneliness. A larger percentage of individuals with high worry reported poor mental health beyond the clinical threshold for each of the mental health outcomes along with high loneliness with 32.3% (n = 368) of high worry individuals reporting depression, 26.2% (n = 298)

Table 2b. Effects of COVID-related worry and rumination on depression, anxiety, wellbeing and loneliness across the six waves including moderating effects on mental and physical health status.

		Unadjusted					Adjusted for covariates			
		Coeff	SE	d.f.	p value		Coeff	SE	d.f.	p value
Depression										
Intercept	β_{00}	5.42	0.125	1942	<0.001	β_{00}	8.856	0.719	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−1.351	0.224	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.364	0.218	1937	0.096
Age	β_{03}	–	–	–	–	β_{03}	−1.991	0.322	1937	<0.001
Mental Health	β_{04}	–	–	–	–	β_{04}	5.572	0.296	1937	<0.001
Physical Health	β_{05}	–	–	–	–	β_{05}	0.556	0.234	1937	0.018
Level 1 slope										
Worry - depression	β_{10}	0.554	0.034	1942	<0.001	β_{10}	0.281	0.047	1940	<0.001
MH * worry – depression	β_{14}	–	–	–	–	β_{14}	0.357	0.093	1940	<0.001
PH * worry – depression	β_{15}	–	–	–	–	β_{15}	−0.056	0.071	1940	0.429
Level 1 slope										
Rumination – depression	β_{20}	0.555	0.036	1942	<0.001	β_{20}	0.352	0.053	1940	<0.001
MH * rumination – depression	β_{21}	–	–	–	–	β_{21}	0.113	0.086	1940	0.188
PH * rumination – depression	β_{22}	–	–	–	–	β_{22}	−0.092	0.074	1940	0.213
Level 1 slope										
Wave – depression	β_{30}	−0.060	0.020	1942	0.003	β_{30}	0.021	0.018	1942	0.263
Anxiety										
Intercept	β_{00}	4.540	0.106	1942	<0.001	β_{00}	8.103	0.586	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−1.407	0.187	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.062	0.185	1937	0.737
Age	β_{03}	–	–	–	–	β_{03}	−1.407	0.187	1937	<0.001
Mental Health	β_{04}	–	–	–	–	β_{04}	4.654	0.251	1937	<0.001
Physical Health	β_{05}	–	–	–	–	β_{05}	0.290	0.200	1937	0.147
Level 1 slope										
Worry – anxiety	β_{10}	0.342	0.183	1937	<0.001	β_{10}	0.323	0.035	1940	<0.001
MH * worry – anxiety	β_{11}	–	–	–	–	β_{11}	0.293	0.074	1940	<0.001
PH * worry – anxiety	β_{12}	–	–	–	–	β_{12}	−0.000	0.061	1940	0.991
Level 1 slope										
Rumination – anxiety	β_{20}	0.584	0.028	1937	<0.001	β_{20}	0.343	0.037	1940	<0.001
MH * rumination – anxiety	β_{21}	–	–	–	–	β_{21}	0.110	0.065	1940	0.091
PH * rumination – anxiety	β_{22}	–	–	–	–	β_{22}	−0.098	0.058	1940	0.090
Level 1 slope										
Wave – anxiety	β_{30}	−0.110	0.016	1942	<0.001	β_{30}	−0.016	0.014	1942	0.267
Wellbeing										
Intercept	β_{00}	23.221	0.127	1942	<0.001	β_{00}	19.94	0.706	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	0.550	0.245	1937	0.025
SEG	β_{02}	–	–	–	–	β_{02}	−0.322	0.237	1937	0.024
Age	β_{03}	–	–	–	–	β_{03}	2.060	0.319	1937	<0.001
Mental Health	β_{04}	–	–	–	–	β_{04}	−4.847	0.264	1937	<0.001
Physical Health	β_{05}	–	–	–	–	B_{05}	0.551	0.245	1937	0.025
Level 1 slope										
Worry – wellbeing	β_{10}	−0.507	0.033	1942	<0.001	β_{10}	−0.339	0.044	1940	<0.001
MH * worry – wellbeing	β_{11}	–	–	–	–	β_{11}	−0.171	0.081	1940	0.036
PH * worry – wellbeing	β_{12}	–	–	–	–	β_{12}	0.189	0.071	1940	0.008
Level 1 slope										
Rumination – wellbeing	β_{20}	−0.499	0.034	1942	<0.001	β_{20}	−0.270	0.048	1940	<0.001
MH * rumination – wellbeing	β_{21}	–	–	–	–	β_{21}	0.011	0.071	1940	0.872
PH * rumination – wellbeing	β_{22}	–	–	–	–	β_{22}	−0.060	0.070	1940	0.390
Level 1 slope										
Wave – wellbeing	β_{30}	0.137	0.019	1942	<0.001	β_{30}	0.065	0.019	1942	<0.001
Loneliness										
Intercept	β_{00}	5.064	0.039	1942	<0.001	β_{00}	6.169	0.218	1937	<0.001
Gender	β_{01}	–	–	–	–	β_{01}	−0.455	0.075	1937	<0.001
SEG	β_{02}	–	–	–	–	β_{02}	0.133	0.075	1937	0.076
Age	β_{03}	–	–	–	–	β_{03}	−0.496	0.097	1937	<0.001
Mental Health	β_{04}	–	–	–	–	β_{04}	1.203	0.086	1937	<0.001
Physical Health	β_{05}	–	–	–	–	β_{05}	−0.067	0.080	1937	0.406
Level 1 slope										
Worry – loneliness	β_{10}	0.051	0.010	1942	<0.001	β_{10}	0.054	0.014	1940	<0.001
MH * worry – loneliness	β_{11}	–	–	–	–	β_{11}	0.037	0.023	1940	0.111
PH * worry – wellbeing	β_{12}	–	–	–	–	β_{12}	−0.034	0.022	1940	0.113
Level 1 slope										
Rumination – loneliness	β_{20}	0.066	0.010	1942	<0.001	β_{20}	0.055	0.015	1940	<0.001
MH * rumination – loneliness	β_{21}	–	–	–	–	β_{21}	0.026	0.023	1940	0.267
PH * rumination – loneliness	β_{22}	–	–	–	–	β_{22}	0.005	0.023	1940	0.807
Level 1 slope										
Wave – loneliness	β_{30}	−0.009	0.006	1942	0.107	β_{30}	−0.009	0.006	1942	<0.115

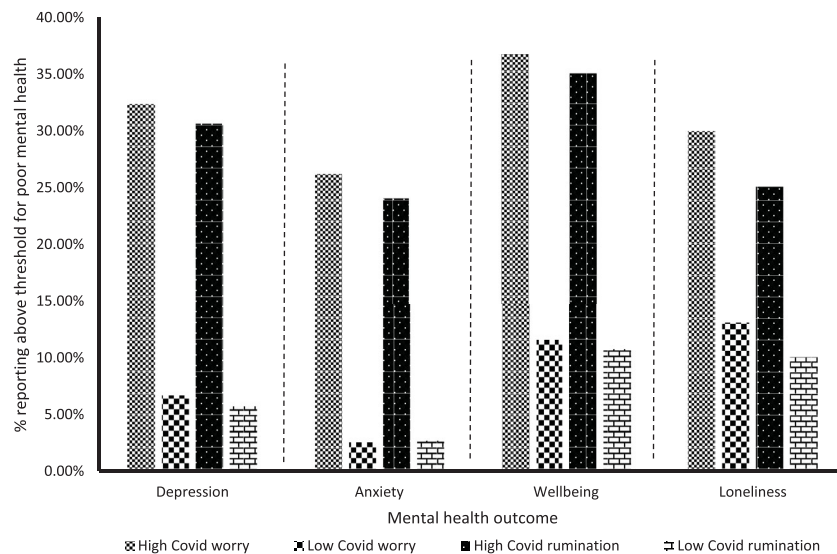*Note*: MH is mental health status; PH is physical health status.

Figure 3. The proportion of participants with high and low Covid-related worry/rumination that meet the threshold for poor mental health. *Poor mental health as indicated by a score of >10 on the PHQ-9 and GAD, a score of <19.3 on the SWEMWBS, and a score of ≥7 on the UCLA-3.

reporting anxiety, 36.8% ($n = 420$) reporting low wellbeing, and 29.9% ($n = 229$) reporting high loneliness scores. In individuals reporting low worry, 6.7% ($n = 55$) reported depression beyond the threshold, 2.6% ($n = 22$) reported anxiety, 11.6% ($n = 93$) reported low wellbeing, and 13.1% ($n = 155$) reported high loneliness.

This pattern was similar when comparing individuals reporting high and low levels of rumination. 30.6% ($n = 383$) of individuals reporting high rumination also reported depression levels above the threshold, these figures were 24.0% ($n = 301$), 35.1% ($n = 439$), 25.1% ($n = 315$) for anxiety, wellbeing, and loneliness respectively. In individuals reporting low rumination, 5.7% ($n = 39$); 2.8% ($n = 19$); 10.8% ($n = 74$); 10.1%, ($n = 70$) reported depression, anxiety, well-being, and loneliness beyond the threshold.

We then looked at the proportion of participants reporting above the mental health clinical thresholds in individuals reporting mental health conditions and high and low levels of worry. Of the participants with mental health conditions who reported high worry, 63.3% ($n = 167$) reported depression above the threshold compared to 31.6% ($n = 66$) of those reporting low worry. In participants not reporting mental health conditions, 27.6% ($n = 135$) of those reporting high worry reported depression scores above the threshold compared to 5.8% ($n = 56$) of those reporting low worry. This pattern was also demonstrated with anxiety as the outcome, as well as in participants who reported physical health conditions with well-being as the outcome (Figure 4; Supplementary Table 3).

Discussion

The current study aimed to track worry and rumination (perseverative cognition) levels during the COVID-19 pandemic and to investigate whether periods with higher levels of worry and rumination were associated with more negative mental health outcomes and loneliness in the UK population. The results showed that COVID-related worry and rumination levels were highest at the beginning of the pandemic (31st March to 9th April 2020) but that they declined steadily across the six waves of the study, however, they started to increase again when the UK returned to lockdown in November 2020. Throughout all six waves, the COVID-related worry component of perseverative cognition was found to be significantly higher than the rumination component. Most importantly, we also found that higher levels of COVID-related worry and rumination were robustly associated with higher levels of depression, anxiety, loneliness, and lower levels of wellbeing across the 9 months of this investigation, and the effects on anxiety and depression were most pronounced in individuals living with a mental health condition.

The findings of the current study show that levels of worry and rumination were highest at the beginning of the pandemic and that they declined steadily throughout the early and middle phases. We are unaware of any other published longitudinal study that has tracked COVID-related worry and rumination over the pandemic or that has investigated whether weeks with higher COVID-related worry/rumination were associated with more negative mental health outcomes. A small number of studies have investigated the effects of worry/rumination early in the pandemic (e.g., Bajaj et al., 2020; Bakker & van Wingerden, 2021). For example, Bajaj and colleagues (2020) showed that COVID-related worry was associated with more severe depressive symptoms during the initial 21-days of the first lockdown in India (starting 25th March 2020). Similarly, Bakker and van Wingerden (2021) found that rumination about COVID predicted increased depressive symptoms and exhaustion, as well as decreased vigor, in a study conducted in the Netherlands (in May 2020). Our findings highlight the continued impact of COVID-related worry and rumination on mental health outcomes throughout the first 9 months of the pandemic. In addition, they show alarmingly high rates of clinically significant levels of anxiety and depression in individuals who reported high levels of COVID-related
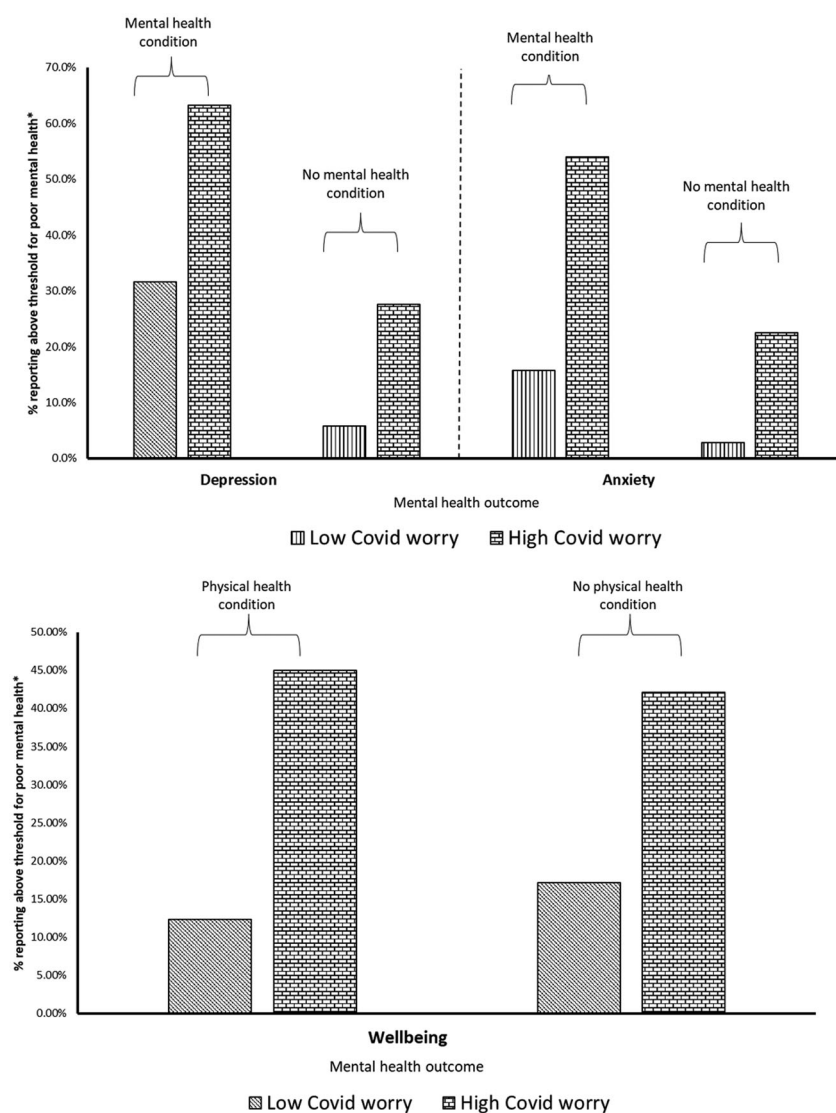
Figure 4. The proportion of participants with high and low Covid-related worry/rumination reporting clinically meaningful levels of anxiety and depression by mental health condition (upper panel) and poor wellbeing by physical health condition (lower panel). Note: Clinically meaningful levels were indicated by a score of >10 on the PHQ-9 and GAD, and a score of <19.3 on the SWEMWBS.

worry and rumination compared to those who reported low levels of COVID-related worry and rumination. Put differently, there was approximately a five-fold and ten-fold increase in individuals scoring above the clinical threshold for depression and anxiety (respectively) when high levels of COVID-related worry were compared to low levels. Similar rates were found when comparing high versus low rumination levels and the pattern of results was comparable for wellbeing.

The findings in relation to loneliness are also noteworthy as they show that COVID-related worry and rumination were associated with a range of psychological outcomes and not restricted to key indicators of mental health such as anxiety and depression. Other research has explored the prevalence and predictors of loneliness during the COVID-19 pandemic and found that over one-third of a large sample of UK participants reported sometimes or often feeling lonely (e.g., Li & Wang, 2020). In particular, Li and Wang (2020) found that females, younger people, not living with a partner, and not being in paid employment were associated

with higher odds of loneliness. The current findings highlight that in addition to socio-demographic factors, important psychological variables such as perseverative cognition processes are implicated in understanding differences in feelings of loneliness and isolation during COVID-19.

We also show that negative, repetitive thoughts about feared future events (worry) associated with the pandemic loomed larger in people's minds than negative repetitive thoughts triggered about past COVID-related events (rumination). The latter finding likely reflects the high levels of fear and uncertainty triggered by the announcement of government restrictions on our everyday activities, the effects of isolation, and the alarming increases in infection and mortality rates together with no clear end in sight (Holmes et al., 2020; O'Connor et al., 2020a). However, the high levels of COVID-related worry in particular may also have been influenced by the extensive and unrelenting media coverage (Holmes et al., 2020; Garfin et al., 2020; Thompson et al., 2017). For example, Sell et al. (2017) have previously shown that media messaging about infectious

diseases can increase perceptions of public risk and anxiety. More recently, based on work from previous public health crises (i.e., Ebola and H1N1 outbreaks), Garfin et al. (2020) have highlighted similar concerns in relation to the COVID-19 pandemic. These authors have argued that repeated exposure to the crisis may lead to increased anxiety and elevated stress responses that may lead to future negative health effects. Moreover, a number of key reviews have shown that elevated levels of worry and rumination (or perseverative cognition) are associated with a range of physiological health outcomes; including higher blood pressure and heart rate, lower heart rate variability, as well increased cardiovascular activity, reduced secretion of antibody productions, blunted cortisol response and increased levels of somatization (O'Connor et al., 2021; Ottaviani et al., 2016; Verkuil et al., 2010). Therefore, as suggested by Garfin et al. (2020), it is important for the media to try to present key public health crisis information in a balanced manner that is not sensationalised or with an abundance of disturbing images and it is recommended that members of the public rely on authoritative sources such as national public health authorities or the World Health Organisation.

Another important finding from the current study was that the effects of worry on mental health were much more pronounced in individuals who were living with a pre-existing mental health condition, but not those living with a pre-existing physical health condition. The latter is perhaps surprising in that individuals with pre-existing physical health conditions might be expected to also report higher anxiety and lower well-being (Fancourt et al., 2021; Özdin & Bayrak Özdin, 2020; Smith et al., 2020). Nevertheless, a growing number of studies have now been published that have shown that the pandemic is disproportionately impacting vulnerable groups (Fancourt et al., 2021; O'Connor et al., 2020a; Pierce et al., 2020; 2021; Vindegaard & Benros, 2020), and in particular individuals with pre-existing mental health conditions. For example, results from waves 1 to 3 of UK COVID-MH study found that individuals with an existing mental health condition were over 5 times more likely to experience suicide ideation compared to those without (O'Connor et al., 2021). Similarly, Pierce et al. (2021) reported that individuals who experienced deteriorating or consistently poor mental health throughout this crisis were more likely to have a pre-existing mental health condition. However, the current findings are particularly noteworthy as they indicate that increases in COVID-related worry may help explain, in part, why individuals with pre-existing mental health conditions have been unequally affected by the pandemic.

Taken together, the findings from this study have implications for public health policy and mental health interventions as we continue to emerge from the current pandemic and for any future public health crises. In terms of mental health interventions, it is clear that individuals with pre-existing mental health conditions should be prioritised as early as possible in order to receive dedicated, easy to access, (remote) clinical services tailored to their needs (O'Connor et al., 2020b). In particular, our findings suggest that mental health interventions should include components that specifically target COVID-related worry and ruminative tendencies. A recent meta-analysis has identified a broad variety of interventions that can reliably reduce worry and rumination, in particular, approaches that encourage individuals to challenge their thinking style, to disengage from the emotional response brought on by worry or rumination as well as mindfulness-based approaches (McCarrick et al. 2021; see also Hansen et al., 2021). This meta-analysis also notes that many of the available interventions are brief, inexpensive, can be self-administered, and delivered online. Interventions that promote psychological flexibility (i.e., mindfulness, self-compassion) are also likely to yield benefits (Prudenzi et al., 2022). Nevertheless, more broadly, if remote delivery of psychological interventions is to become an effective and beneficial part of an evolved mental health service, then we urgently need to further understand how to provide that 'webside' manner that will increase adherence and promote a therapeutic alliance (O'Connor et al., 2020a).

We recognise that there are a number of limitations of the current study. Despite successfully recruiting a quota-based national sample, similar to all studies that recruit via digital means, our sample may underestimate the mental health effects of COVID-19 as those who are digitally excluded may be underrepresented. Relatedly, individuals who did not complete all six waves may have had poorer mental health compared to those that completed all six waves. Nevertheless, the strengths of the current design are that we followed a large number of individuals throughout the first 9 months of the COVID-19 pandemic allowing each participant to act as their own control during weeks when they experienced higher compared to lower levels of COVID-related worry and rumination. In addition, it is worth noting that the results were very similar when the models were run in multiply imputed datasets.

In conclusion, the current study showed that COVID-related worry and rumination levels were highest at the beginning of the pandemic and declined steadily across the six waves with an increase when the UK returned to lockdown. COVID-related worry levels were found to be consistently higher than rumination levels. Most importantly, higher levels of COVID-related worry and rumination were robustly associated with higher levels of depression, anxiety, and loneliness and lower levels of wellbeing across the 6 waves, and these effects were most marked in individuals living with a pre-existing mental health condition. Psychological interventions should include components that specifically target COVID-related worry and rumination and individuals with pre-existing mental health conditions should be prioritised as early as possible as we emerge from the current pandemic and in any future public health crises.

Disclosure statement

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