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ORIGINAL ARTICLE

Observational Study

Impact of lockdown relaxation and implementation of the face-covering policy on mental health: A United Kingdom COVID-19 study

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Author contributions: Rathod S, Rathod P and Phiri P developed the study protocol and questionnaire; Rathod S, Phiri P, Soomro MG, and Rahman MM contributed to the manuscript development; Rahman MM conducted the analysis; all authors reviewed and approved the final version of the manuscript.

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Abstract

BACKGROUND

Pandemic mitigation policies, such as lockdown, are known to impact on mental health of individuals. Compulsory face covering under relaxed lockdown restrictions gives assurance of less transmission of airborne infection and has the potential to improve mental health of individuals affected by restrictions.

AIM

To examine the association of the lockdown relaxation and the implementation of the face covering policy on the mental health of the general population and sub-groups in the United Kingdom using interrupted time series model.

METHODS

Using a web-based cross-sectional survey of 28890 United Kingdom adults carried out during May 1, 2020 to July 31, 2020, changes in mental health status using

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generalised anxiety disorder (GAD-7), and impact of events scale-revised (IES-R) scales are examined, at the dates of the first lockdown relaxation (July 4, 2020) and the subsequent introduction of face covering (July 24, 2020) in United Kingdom. A sharp regression discontinuity design is used to check discontinuities in mental health outcomes at policy-change dates.

RESULTS
Average GAD-7 scores of participants were 5.6, 5.6 and 4.3 during the lockdown period, the lockdown relaxation phase and the phase of compulsory face covering, respectively, with lower scores indicating lower anxiety levels. Corresponding scores for IES-R were 17.3, 16.8 and 13.4, with lower scores indicating less distress. Easing lockdown measures and subsequent introduction of face covering, on average, reduced GAD-7 by 0.513 (95%CI: 0.913-0.112) and 1.148 (95%CI: 1.800-0.496), respectively. Corresponding reductions in IES-R were 2.620 (95%CI: 4.279-0.961) and 3.449 (95%CI: 5.725-1.172). These imply that both lockdown relaxation and compulsory face-covering have a positive association with mental health scores (GAD-7 and IES-R).

CONCLUSION
The differential impact of lockdown and relaxation on the mental health of population sub-groups is evident in this study with future implications for policy. Introduction of face covering in public places had a stronger positive association with mental health than lockdown relaxation.

Key Words: COVID-19; Psychological impact; Lockdown; Face-covering; Mental health; Anxiety

Core Tip: Positive association of lockdown relaxation and face-covering policies on the mental health (MH) of various population sub-groups is reported. Professional groups and health workers had lower generalised anxiety disorder (GAD-7) scores than other workers. During the compulsory face-covering phase, all professional groups improved on GAD-7 and impact of events scale-revised (IES-R) scores. Significant improvements in MH scores were found among non-key workers. Gender was associated with different MH outcomes during the lockdown, with females scoring higher on the GAD-7 and IES-R scales than males. However, both groups showed a significant improvement in MH status during the period of face-covering, with slightly higher improvements noted in males.

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INTRODUCTION

Restriction of people's movements and interactions following wide-spread transmission of coronavirus disease 2019 (COVID-19) has been experienced by the global community. Several countries in the world have implemented lockdown measures to contain the spread of infection and/or delay the spread of infection in order to reduce mortality and morbidity.

The United Kingdom government implemented national lockdown in England on March 23, 2020. The restrictions imposed by the lockdown impacted on the health, economic and social welfare of individuals, households and society[1]. Lockdown reduced educational performance and nutrition of United Kingdom children caused by junk food intake[2]. Although it improved roadside air quality in the United

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Kingdom because of the reduction of vehicles[3], there was £370 billion loss to the United Kingdom economy[4] in addition to the loss of human lives and health[5].

The lockdown measures were first relaxed on July 4, 2020 and further changes, primarily the compulsory use of face covering in shops, were introduced on July 24, 2020. Table 1 summarises relaxation measures and face covering policy introduced following lockdown on March 23, 2020. Policy makers and mental health care providers need to know the reliable estimates of such effects to target policies and services to mitigate the mental health impact of restrictive measures due to COVID-19.

Globally, there is evidence of mental health decline among the general population during the COVID-19 pandemic. China, Spain, Italy, Iran, the United States, Turkey, Nepal, and Denmark, reported relatively higher rates of symptoms of anxiety (6.33% to 50.9%), depression (14.6% to 48.3%), post-traumatic stress disorder (7% to 53.8%), psychological distress (34.43% to 38%), and stress (8.1% to 81.9%) among the general population[6]. Stay-at-home orders, greater reduction of social contacts and perceived changes in everyday life were the primary pathways to increased mental health problems[7].

In the United Kingdom, there is evidence of minor psychiatric disorders during the first month of lockdown. For example, generalized health questionnaire (GHQ-12) reported an increase of 0.48 (95%CI: 0.07–0.90) from 2018-19 to April, 2020[1]. Daly *et al* [8] also found a similar increase in GHQ-12 in the United Kingdom. The highest increases of GHQ-12 are seen among 18–24 years old (2.69 points, 95%CI: 1.89–3.48), 25–34 years old (1.57, 95%CI: 0.96–2.18), women (0.92, 95%CI: 0.50–1.35), and people living with young children (1.45, 95%CI: 0.79–2.12). The mental health of United Kingdom adults was slightly better at the early stages of lockdown than at the end of lockdown[9]. Suicidal thoughts increased during lockdown, especially among young United Kingdom adults[10]. However, the mental health effects of COVID-19 on United Kingdom healthcare professionals are ambiguous[11], and some studies found a positive impact of the pandemic on the mental health of this specific group in the United Kingdom[12,13]. A key limitation of these studies is that they did not undertake causal analyses, which is key for policy and programming. Further, there is a need to evaluate the impact of face covering policy on the mental health of different population sub-groups.

Altschul *et al*[14] captured associations of face-covering with the mental health of United Kingdom adults using the logit model and concluded that wearing face coverings more often does not negatively impact mental health. Mental health impact of face covering may be due to the confidence people felt, particularly those vulnerable, with regard to the protection it might offer from infection. Face covering was promoted with medical narrative[15] and hence its use was primarily seen as a medical intervention. It is important to understand whether such intervention provides mental health improvements. This paper addresses the research gap by trying to capture any associations of COVID-19 restrictions and their easing with key policies on the mental health of United Kingdom adults with special focus on population sub-groups. The authors used sharp regression discontinuity design (RDD) to analyse discontinuities in mental health outcomes at key policy-change dates. We also tested the key identification condition, the local randomization. If the factors affecting mental health outcomes were not found discontinuous at those cut-off dates, discontinuities in mental health outcomes were likely to be causal given other identification conditions (*e.g.*, unconfoundedness) hold[16]. There is no formal way of testing them, but this can be checked informally through falsification tests (*e.g.*, checking discontinuities in mental health outcomes at any false dates, checking false outcomes at lockdown policy changing dates). In this study, we consider the informal test through visual inspection of figures.

MATERIALS AND METHODS

Data

A cross-sectional online international survey of adults, 16 years and above, was carried out during May 1, 2020 to July 31, 2020 yielding a sample size of 28890 in England. Further details of the methodology are documented in an earlier publication by the group[13]. Of the total sample, 20174 completed the online questionnaire during lockdown; 4550 during the first phase of relaxation and 4145 during the face covering policy period.

Table 1 Lockdown relaxations in the United Kingdom

Date	Policy changes
July 4, 2020	2-metre distance rule was dropped
	Members of two different households have been able to drink or dine together
	Households will be able to host visitors, including overnight, and to meet with members of different households, on different occasions – including in a pub, restaurant or hotel, for example
	To reopen pubs, campsites, hairdressers, and churches. All these venues will be expected to collect and keep the contact details of visitors, so they can be traced in the event of a local outbreak of the virus
	Theatres and concert halls will also be able to reopen but they cannot host live performances because of concerns including the risk that singing can transmit the virus
July 24, 2020	Face mask has become compulsory in shops

Southern Health National Health Service (NHS) Foundation Trust co-ordinated the online survey with support from 50 NHS Trusts, Universities, and The Centre for Applied Research and Evaluation International Foundation. These organisations advertised the survey to their staff, patients and the general public with a weblink to the survey platform. Overall, more than 100 organizations were involved in sending the survey links to potential participants *via* professional routes and social media (Figure 1).

Study design

To study the impact of easing lockdown and introduction of face covering on mental health, both control and experimental groups are required. However, as the first United Kingdom lockdown was implemented at national level, there was no control group (*i.e.* areas without lockdown) available naturally within the nation to identify the impact of easing lockdown measures on mental health. In the absence of such control population, the RDD model is the most suitable method to address the objectives. As the United Kingdom lockdown and face covering policy had clear implementation protocols, including exact date and time, it was easier to identify cut-off points for policy change required for the chosen method. As far as we know there was no other policy announcement that might affect the mental health of the population to contaminate the effect. The two cut-off points (date of first lockdown easing and introduction of face covering) were July 4, 2020 and July 24, 2020, respectively. The RDD methodology allows for the creation of control and experimental groups by identifying populations with the same characteristics just before and after each cut-off date (*i.e.* July 4, 2020 and July 24, 2020). The population before the cut-off date serves as the control group and the after the cut-off date will be the experimental group. This creates two sets of control and experimental groups, one set at each cut-off date generating a quasi-experimental design.

The study received ethics and HRA approval. IRAS project ID: 282858; REC reference: 20/HRA/1934 from London-Westminster Research Ethics Committee on 27 April 2020.

Diagnostics

To test whether the data qualifies for RDD, predicted values of generalised anxiety disorder (GAD-7) and impact of events scale-revised (IES-R) are plotted against the interview end date (Figures 2 and 3). Vertical lines indicate cut-off dates. As data are highly scattered, figures without vertical lines (at the cut-off dates) and fitted lines will cause difficulty in understanding discontinuities at the cut-off dates. Predicted values are generated from regressions of these indices on the trend variable allowing discontinuities and changes in slopes. These predicted values pass through scatter points, which are daily averages of these indices. The interview end date is the date of completing the survey questionnaire by an individual. Interview end dates are used to make the trend variable (*e.g.*, 1 for first date, 2 for second date, *etc.*), and this gives the appropriate assignment variable. The two mental health measures show clear negative discontinuities at the first and second cut-off dates, implying that easing lockdown restrictions and introduction of face covering improved mental health.

Visual inspection of the two figures indicates slope changes after the first cut-off date. In survey data, such slope changes can be difficult to interpret. The analysis captures intercept discontinuities (steps) after also controlling for slope changes, as

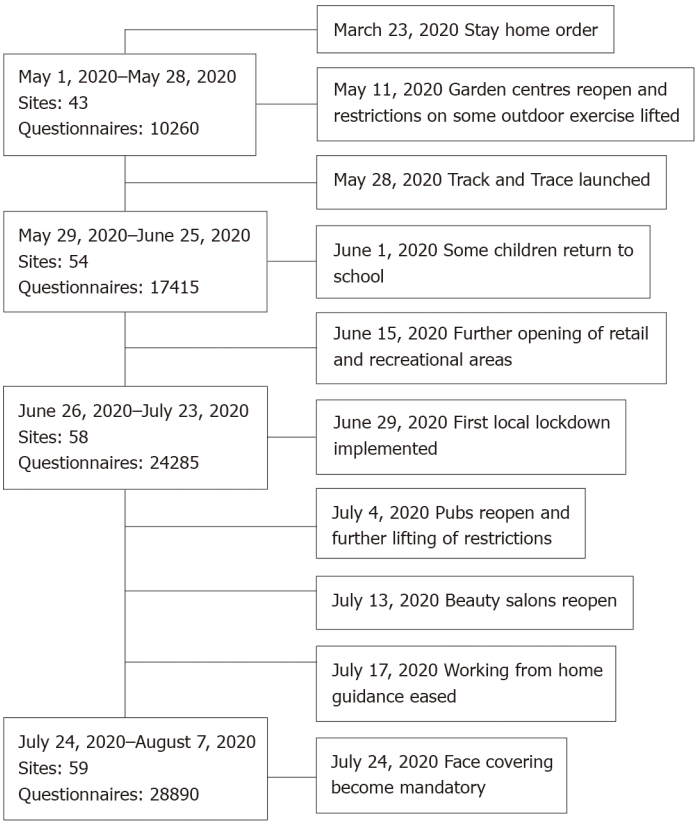

Figure 1 Survey recruitment and significant lockdown dates.

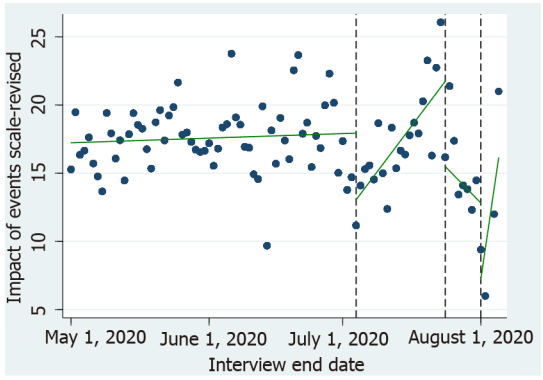

Figure 2 Discontinuities in impact of event scale-revised scale at two cut-off dates.

suggested by Angrist and Pischke[17] in RDD.

Modelling

The unit of analysis is an adult aged 16 years or over. The outcome of interest, mental health outcome measured using GAD-7 and IES-R, is denoted by Y, which varies across different groups of individuals (*e.g.*, health *vs* non-health workers, male *vs* female, *etc.*) by date. For purposes of regression, date is used as the trend variable, which contains 1 for the first date, 2 for the second date, and so on. Individual and time are indicated by i and t, respectively. As mental health conditions change around the cut-off time, the following RDD type of interrupted time series model was used:

$$Y_{it} = \alpha + \beta_1 d_{t1} + \beta_2 d_{t2} + \beta_3 d_{t1}(Trend_t\text{-}c_1) + \beta_4 d_{t2}(Trend_t\text{-}c_2) + \beta_5(Trend_t\text{-}c_1) + X_{it}\theta + \epsilon_{it}$$

where α is the constant term, d_{t1} = *1{Interview end date* ≥ 4^{th} *of July}*, and d_{t2} = *1{Interview end date* ≥ 24^{th} *of July}* are discontinuity dummies, c_1 = *Value of trend for the date of* 4^{th} *of July* and c_1 = *Value of trend for the date of* 24^{th} *of July* the two cut-off points, X_{it} is the row vector of control variables (listed in Tables 2 and 3) and θ is the column vector of their coefficients, and $\in_{it}$ is the error term. β_1 and β_2 are parameters of discon-

Table 2 Sampling distribution of mental health outcomes, demographics, lifestyle changes, and pre-existing health conditions by lockdown periods

Time by lockdown easing policy	May 1, 2020-July 3, 2020 (Lockdown phase)		July 4-23, 2020 (Lockdown relaxation phase)		July 24-31, 2020 (Face-covering phase)		Total		
Outcome and control variables	No.	%	No.	%	No.	%	No.	%	*P* value
Total sample	20173	100	4550	100	4145	100	28890	100	
Mental health outcomes/scores									
GAD-7									
Total	15634	100	3379	100	3153	100	22166	100	
Missing	4539		1171		992		6711		
IES-R									
Total	14516	100	3141	100	2961	100	20618	100	
Missing	5657		1409		1184		8260		
Demographics, lifestyle changes, and pre-existing health conditions									
Key worker									
No	5400	29.7	1260	31.4	1778	48.8	8438	32.6	
Yes (health)	9205	50.6	1961	48.9	1161	31.8	12327	47.7	
Yes (non-health)	3595	19.8	793	19.8	708	19.4	5096	19.7	
Total	18200	100	4014	100	3647	100	25861	100	< 0.001
Missing	1973		536		498		3014		
Gender									
Female	15324	84.2	3331	83.4	2701	75.2	21356	82.8	
Male	2872	15.8	662	16.6	891	24.8	4425	17.2	
Total	18196	100	3993	100	3592	100	25781	100	< 0.001
Missing	1977		557		553		3094		
Age category or group									
Under 21	332	1.8	90	2.2	81	2.2	503	1.9	
21-24	828	4.5	163	4	100	2.7	1091	4.2	
25-34	3627	19.8	709	17.5	566	15.4	4902	18.8	
35-44	4076	22.2	794	19.5	712	19.4	5582	21.4	
45-54	4676	25.5	1008	24.8	851	23.2	6535	25.1	
55-64	3462	18.9	882	21.7	795	21.6	5139	19.7	
65 and over	1319	7.2	416	10.2	568	15.5	2303	8.8	
Total	18320	100	4062	100	3673	100	26055	100	< 0.001
Missing	1853		488		472		2820		
Ethnicity									
Non-white British	1649	9	362	8.9	351	9.5	2362	9.1	
White British	16703	91	3698	91.1	3325	90.5	23726	90.9	
Total	18352	100	4060	100	3676	100	26088	100	< 0.001
Missing	1821		490		469		2787		
Religion									
Non-Christian	9794	54.1	2140	54.3	1905	53.8	13839	54.1	
Christian	8306	45.9	1798	45.7	1633	46.2	11737	45.9	

Total	18100	100	3938	100	3538	100	25576	100	0.911
Missing	2073		612		607		3300		
Age left education									
≤ 18 (A-level or less)	5967	33	1557	38.9	1249	34.4	8773	34.1	
> 18 (Higher degree)	12118	67	2442	61.1	2381	65.6	16941	65.9	
Total	18085	100	3999	100	3630	100	25714	100	
Missing	2088		551		515		3161		
Accommodation									
Rented home	5030	27.5	1163	28.7	847	23	7040	27	
Own home	13288	72.5	2891	71.3	2834	77	19013	73	
Total	18318	100	4054	100	3681	100	26053	100	< 0.001
Missing	1855		496		464		2822		
Vulnerable according to government category									
No	13735	80.6	2938	78.5	2610	77.7	19283	79.8	
Yes (do not require shielding)	2005	11.8	503	13.4	494	14.7	3002	12.4	
Yes (require shielding)	1307	7.7	303	8.1	257	7.6	1867	7.7	
Total	17047	100	3744	100	3361	100	24152	100	< 0.001
Missing	3126		806		784		4725		
Experienced coronavirus									
No	4354	24.9	1016	26.3	971	27.8	6341	25.5	
Yes	13152	75.1	2843	73.7	2518	72.2	18513	74.5	
Total	17506	100	3859	100	3489	100	24854	100	0.001
Missing	2667		691		656		4022		
Pre-existing mental health condition									
No	10685	62.6	2288	60.8	2404	70.1	15377	63.3	
Yes	6395	37.4	1476	39.2	1026	29.9	8897	36.7	
Total	17080	100	3764	100	3430	100	24274	100	< 0.001
Missing	3093		786		715		4604		
Drinking alcohol									
Never	2611	14.6	540	13.7	492	13.8	3643	14.4	
Monthly or less	3954	22.2	944	24	692	19.4	5590	22.1	
2-4 times a month	3909	21.9	930	23.6	824	23	5663	22.3	
2-3 times a week	4873	27.3	1007	25.6	999	27.9	6879	27.1	
4 times or more a week	2479	13.9	520	13.2	569	15.9	3568	14.1	
Total	17826	100	3941	100	3576	100	25343	100	< 0.001
Missing	2347		609		569		3532		
Taking drug									
No	17354	97.9	3810	97.3	3465	97.3	24629	97.7	
Yes	369	2.1	107	2.7	95	2.7	571	2.3	
Total	17723	100	3917	100	3560	100	25200	100	< 0.001
Missing	2450		633		585		3675		
Suicidal thoughts									

No	12015	68.3	2591	66.7	2521	71.5	17127	68.5	
Yes	5572	31.7	1292	33.3	1005	28.5	7869	31.5	
Total	17587	100	3883	100	3526	100	24996	100	< 0.001
Missing	2586		667		619		3879		

GAD-7: Generalised anxiety disorder-7; IES-R: Impact of events scale-revised.

tinuities at two respective cut-off dates, and β_3 and β_4, are parameters of kinks (slope changes) at two respective cut-off dates. Parameters of interest in this paper are discontinuity parameters, β_1 and β_2, which give changes in mental health scores at the two cut-off dates.

The control variables included in the analysis are socio-demographic characteristics (*e.g.*, profession, age, ethnicity, religion, gender, education, accommodation, *etc.*), lifestyle characteristics (*e.g.*, experiencing coronavirus, drug use, drinking alcohol, *etc.*), and pre-existing health conditions (*e.g.*, vulnerability, suicidal thoughts, mental health conditions). The outcome variable of interest is mental health status. Two widely used standardized measures have been used to measure levels of anxiety (GAD-7)[18], and subjective distress (IES–R)[19]. The GAD-7 ranges from 0 to 21, and it categorizes as minimal (0-4), mild (5-9), moderate (10-14), and severe (15-21). The IES-R ranges from 0 to 88, and it categorizes as minimal (0-23), post-traumatic stress disorder (PTSD) may be a concern (24-32), probable PTSD diagnosis (33-38), and high PTSD (39-88). A total of 22,166 respondents completed the GAD-7 questionnaire. Of those 15634 were completed during lockdown, 3379 during the first phase of lockdown relaxation, and 3153 during the face covering phase. A total of 20618 respondents completed the IES-R questionnaire, 14516 respondents completed this during lockdown, 3141 during the first phase and 2961 during the second phase of lockdown relaxation.

Table 2 presents percentage distribution of control variables used in the regressions according to lockdown, lockdown relaxation, and face covering implementation period. It suggests that the proportions of control variables in the three time periods follow a similar pattern. However, there are higher proportions of health workers (31.8%-50.6%) and females (75.2%-84.2%) in the sample. The table shows that (P < 0.001) percentages of control variables vary significantly during each of the time periods. Such discrepancies in demographic characteristics of respondents will not violate identification conditions as discrepancies of those covariates do not exist around the cut-off dates in most cases (*e.g.*, the existence of local randomization available in supplementary material). The table also shows missing values, which are unlikely to make any serious impact on the results of regressions as the individuals are distributed based on comparable characteristics before and after the cut-off dates.

RESULTS

Mental health outcomes by background characteristics

Table 3 provides average scores of the two mental health measures for three time periods: During lockdown; during relaxation and the face covering period. Comparisons of the average scores between these time periods gives us raw estimates of the effects of the lockdown relaxation and the compulsory face covering policies. The average scores of GAD-7 and IES-R at the three time periods suggest that the mental health of the respondents was worse during lockdown but has improved after the lockdown easing and during the period of face covering. For example, the overall mean GAD-7 scores were 5.6 each for the lockdown period and the first phase of lockdown relaxation, compared to 4.4 during the period of face covering. For the IES-R, the average scores were 17.3, 16.8 and 13.4 for the periods of lockdown, lockdown relaxation, and face covering, respectively, suggesting a reduction in anxiety and distress during the first relaxation, but significant reductions were noticed during the period of face-covering.

There were notable differences in the associations of lockdown relaxation and compulsory face covering policies on mental health of various population sub-groups. Among the professional groups, health workers had the lowest GAD-7 score (5.1) compared to other key workers (6.3) and non-key workers (5.8) during the lockdown period. Similar findings were observed for the IES-R, 18.5 for non-key workers, 15.9 for health workers and 19.0 for other key workers. During the compulsory face covering

Table 3 Means of mental health conditions by lockdown easing periods, demographics, lifestyle changes, and pre-existing health conditions

Control variables	Means of GAD-7 (*n* = 18948) (95%CI)			Means of IES-R (*n* = 17739) (95%CI)		
	May 1, 2020-July 3, 2020 (Lockdown)	July 4-23, 2020 (Lockdown relax)	July 24-31, 2020 (Face-covering)	May 1, 2020-July 3, 2020 (Lockdown)	July 4-23, 2020 (Lockdown relax)	July 24-31, 2020 (Face-covering)
Total study population	5.6 (5.5-5.7)	5.6 (5.3-5.8)	4.4 (4.2-4.6)	17.3 (16.9-17.6)	16.8 (16.0-17.6)	13.4 (12.7-14.2)
Key worker						
Not a key worker	5.8 (5.6-6.0)	6.2 (5.7-6.7)	4.1 (3.8-4.4)	18.5 (17.8-19.2)	19.9 (18.2-21.5)	13.1 (12.1-14.2)
Health	5.1 (5.0-5.3)	5 (4.7-5.3)	4.3 (3.9-4.6)	15.9 (15.4-16.3)	14.4 (13.4-15.4)	12.2 (11.0-13.5)
Not in health	6.3 (6.1-6.6)	6.1 (5.5-6.6)	5.3 (4.8-5.9)	19 (18.2-19.8)	18.5 (16.8-20.3)	16.1 (14.4-17.9)
Gender						
Female	5.8 (5.7-5.9)	5.7 (5.5-6.0)	4.8 (4.5-5.1)	18 (17.6-18.4)	17.3 (16.4-18.2)	14.4 (13.5-15.2)
Male	4.3 (4.0-4.5)	4.8 (4.1-5.4)	3.2 (2.8-3.7)	13.3 (12.4-14.1)	14.1 (12.2-16.1)	10.7 (9.4-12.1)
Age group						
Under 21	7.7 (6.8-8.5)	9.3 (6.7-11.9)	8.6 (6.4-10.9)	24 (20.9-27.1)	30.8 (20.8-40.8)	28.8 (20.2-37.3)
21-24	7.9 (7.4-8.5)	7.8 (6.3-9.2)	6.7 (5.0-8.4)	22.6 (20.8-24.3)	21.4 (17.0-25.7)	19.2 (13.9-24.5)
25-34	6.8 (6.5-7.0)	7.5 (7.0-8.1)	5.7 (5.1-6.4)	19 (18.2-19.8)	21.3 (19.4-23.2)	15.4 (13.3-17.4)
35-44	6.1 (5.9-6.3)	6.1 (5.6-6.6)	5.2 (4.7-5.7)	18.3 (17.5-19.0)	17.8 (16.1-19.5)	14.4 (12.8-15.9)
45-54	4.9 (4.7-5.1)	4.8 (4.4-5.3)	4.5 (4.0-5.0)	16.2 (15.6-16.9)	14.5 (13.0-16.0)	13.2 (11.8-14.7)
55-64	4.6 (4.4-4.8)	4.8 (4.3-5.3)	3.7 (3.3-4.1)	15.7 (15.0-16.5)	14.8 (13.2-16.4)	12.6 (11.2-14.0)
65 and over	3.1 (2.8-3.4)	3.1 (2.5-3.7)	1.9 (1.4-2.3)	10.8 (9.7-11.8)	12.2 (9.7-14.6)	8.1 (6.5-9.7)
Ethnicity						
Non-white	4.9 (4.5-5.2)	5.9 (5.1-6.8)	4.9 (4.1-5.7)	15.9 (14.7-17.1)	19.2 (16.3-22.0)	14.4 (12.0-16.8)
White	5.6 (5.5-5.7)	5.5 (5.3-5.8)	4.4 (4.1-4.6)	17.4 (17.0-17.7)	16.6 (15.7-17.4)	13.3 (12.5-14.1)
Religion						
Non-Christian	5.7 (5.6-5.9)	6.0 (5.6-6.3)	4.6 (4.3-4.9)	17.6 (17.2-18.1)	17.6 (16.5-18.7)	13.8 (12.8-14.8)
Christian	5.4 (5.2-5.5)	5.1 (4.8-5.5)	4.2 (3.9-4.5)	16.8 (16.3-17.3)	15.8 (14.6-17.0)	12.9 (11.9-14.0)
Education						
A-level or less	6.2 (6.0-6.4)	6.1 (5.7-6.6)	4.5 (4.1-4.9)	19.1 (18.4-19.8)	19.1 (17.6-20.5)	14.3 (12.9-15.7)
Higher degree	5.3 (5.2-5.4)	5.2 (4.9-5.5)	4.4 (4.1-4.6)	16.4 (16.0-16.8)	15.5 (14.6-16.4)	13 (12.2-13.9)
Type of accommodation						
Rented	7.1 (6.9-7.3)	7.8 (7.3-8.3)	6.7 (6.1-7.3)	21.6 (20.9-22.3)	23.1 (21.4-24.8)	19.7 (17.8-21.6)
Own	5 (4.9-5.1) 4	4.7 (4.5-5.0)	3.8 (3.5-4.0)	15.7 (15.3-16.0)	14.4 (13.5-15.3)	11.7 (10.9-12.4)
Shielding status (government)						
Shielding not required	5.5 (5.4-5.6)	5.5 (5.2-5.8)	4.4 (4.1-4.6)	16.8 (16.5-17.2)	16.2 (15.3-17.1)	12.9 (12.1-13.7)
Shielding required (but not Shielding)	5.5 (5.2-5.9)	5.1 (4.5-5.8)	4 (3.4-4.6)	17.6 (16.5-18.6)	16.6 (14.5-18.8)	13 (11.0-14.9)
Shielding required (shielding)	6.6 (6.2-7.0)	7.4 (6.4-8.5)	5.5 (4.6-6.5)	21.2 (19.8-22.6)	23.9 (20.7-27.2)	19.3 (16.2-22.3)
Experience of COVID-19						
No such experience	5.1 (4.9-5.3)	5.1 (4.6-5.6)	3.9 (3.5-4.4)	15.5 (14.8-16.2)	16.3 (14.7-18.0)	12.1 (10.7-13.5)
Yes	5.7 (5.6-5.8)	5.7 (5.4-6.0)	4.6 (4.3-4.9)	17.8 (17.4-18.2)	17 (16.1-17.9) 1	3.9 (13.1-14.8)
Pre-existing mental health						

No	4.1 (4.0-4.2)	3.7 (3.5-3.9)	3.2 (2.9-3.4)	13 (12.6-13.3)	11.5 (10.7-12.3)	9.7 (9.0-10.4)
Yes	8.2 (8.0-8.4)	8.7 (8.3-9.2)	7.6 (7.1-8.1)	24.9 (24.3-25.6)	25.9 (24.5-27.4)	23 (21.3-24.7)
Drinking alcohol						
Never	6.3 (6.0-6.6)	6.2 (5.5-6.9)	5.7 (4.9-6.4)	19.7 (18.6-20.7)	17.9 (15.6-20.2)	16.2 (13.8-18.6)
Monthly or less	6.2 (6.0-6.5)	6.6 (6.0-7.1)	5 (4.4-5.5)	18.8 (18.0-19.6)	19.5 (17.6-21.3)	15.2 (13.4-17.0)
2-4 times a month	5.4 (5.2-5.6)	5.3 (4.8-5.8)	4.3 (3.8-4.7)	16.7 (15.9-17.4)	17 (15.4-18.5)	13 (11.5-14.5)
2-3 times a week	5 (4.9-5.2) 5	5.2 (4.7-5.6)	3.9 (3.5-4.4)	15.5 (14.9-16.1)	15.2 (13.7-16.7)	12.2 (10.9-13.5)
4 times or more a week	5.1 (4.8-5.3)	4.3 (3.7-5.0)	3.8 (3.2-4.4)	16.9 (16.0-17.9)	13.4 (11.6-15.3)	12 (10.3-13.7)
Drug use						
Never	5.5 (5.4-5.6)	5.5 (5.2-5.7)	4.3 (4.1-4.6)	17.1 (16.8-17.5)	16.6 (15.8-17.4)	13.1 (12.4-13.9)
Ever	7.7 (6.8-8.6)	9.6 (7.9-11.4)	7.3 (5.5-9.1)	23.8 (20.9-26.8)	25.5 (19.9-31.1)	24.2 (18.3-30.0)
Suicidal thoughts ever						
No	4.5 (4.4-4.6)	4.4 (4.1-4.7)	3.4 (3.2-3.7)	13.9 (13.5-14.3)	13.2 (12.3-14.0)	10.3 (9.6-11.0)
Yes	7.8 (7.6-8.0)	8 (7.6-8.5)	6.9 (6.4-7.4)	24.3 (23.7-25.0)	24.4 (22.8-25.9)	21.6 (19.9-23.3)

CI: Confidence intervals; COVID-19: Coronavirus disease 2019; GAD-7: Generalised anxiety disorder-7; IES-R: Impact of events scale-revised.

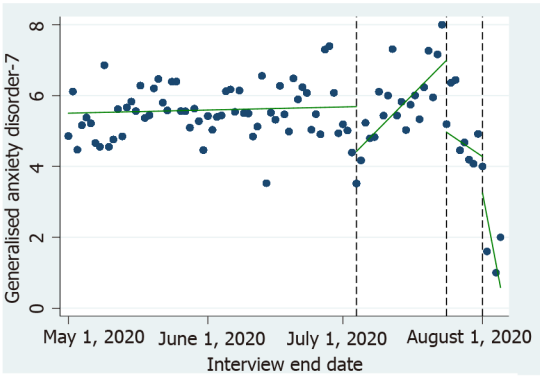

Figure 3 Discontinuities in generalised anxiety disorder-7 scale at two cut-off dates.

phase, there were improvements (mean reductions) in both mean scores for all three professional groups; the GAD-7 and IES-R scores were 4.1 and 13.1 for non-key workers, 4.3 and 12.2 for health workers, and 5.3 and 16.1 for non-health workers during the period of face covering, respectively. These imply that greater improvements in mental health are found among non-key workers than key workers, meaning that non-key workers were affected more by COVID-19. However, the regression results give a better indication.

In this study, gender was associated with mental health outcomes. During the lockdown, females had higher GAD-7 mean scores (5.8) compared to males (4.3). A similar pattern was observed for the IES-R (18.00 for females and 13.3 males). Both groups have shown significant improvements in anxiety and distress during the period of face covering, but slightly higher improvements are seen among males compared to females.

Table 3 further shows that both GAD-7 and IES-R were higher among younger age groups. For example, during lockdown, GAD-7 score was 7.7 for the under 21 years age group compared to 3.1 for the 65+ age group. The IES-R was 24.00 for the below 21 years age group compared to 10.8 for the 65+ age group. Both the scores of all age groups have declined during the face covering period. Compared to the middle age groups (*e.g.*, 35-44, 45-54), higher reductions (at least in terms of percentage) are seen among the lower and higher age groups.

Ethnic variations in mental health were also noted in this study. White ethnic population had higher GAD-7 (5.6) and IES-R (17.4) scores during the lockdown period compared to non-white (GAD-7, 4.9; IES-R, 15.9) ethnic group. Both ethnic groups showed notable improvements in average GAD-7 and IES-R scores at the face covering period, but not during the lockdown relaxation period. The white group shows greater improvements in mental health than the non-white group. Among non-Christians, both GAD-7 (5.7) and IES-R (17.6) scores were higher compared to Christians (GAD-7, 5.4; IES-R, 16.8). Similar to ethnicity, notable improvements in the average anxiety and distress scores of the two measures were noted in the face covering period, but not for the lockdown relaxation period. Slightly greater improvements in mental health are seen among Christians (who are mainly white ethnic population) than non-Christians.

Educational differences in mental health status by lockdown status and face covering were found in this study. During lockdown, average mental health scores for the two measures were higher for those with A-level or less (GAD-7, 6.2; IES-R, 19.1) compared to those with degree qualification (GAD-7, 5.3; IES-R, 16.4). Although there were some improvements in the mental health scores during the first lockdown relaxation, larger improvements were noted in the face covering period. In the face covering period, larger falls in both scores are seen among lower educated groups, implying that this group of educated people that includes lower-skilled workers was possibly hit more by COVID-19. Those who lived in rental accommodation during lockdown experienced more distress, with higher scores for both GAD-7 (7.1) and IES-R (21.6) compared to those living in their own homes (GAD-7, 5.0; IES-R, 15.7). Notable improvements in both GAD-7 and IES-R scores were found in the face covering period, and greater improvements are seen for those who live in their own houses.

During the lockdown period, those who shielded as *per* government advice had higher mental health scores for the two measures (GAD-7 = 6.6; IES-R = 21.2) compared to those who did not shield although they were advised to shield (GAD-7 = 5.5; IES-R = 17.6). Again, improvements in mental health of both groups are seen during the face covering period, but greater improvements are seen among those who shielded. Those who have experienced some COVID-19 related unpleasant experiences, had higher anxiety and distress scores (GAD-7 = 5.7; IES-R = 17.8 during the lockdown phase) compared to those who did not experience such situations (GAD-7 = 5.1; IES-R = 15.5 during the lockdown phase). Their mental health status improved significantly when the face covering policy was introduced. Greater improvement is seen among individuals who experienced coronavirus in IES–R scores. Similarly, those who had pre-existing mental health problems had higher mental health scores in both GAD-7 and IES-R in all three phases. Again, they experienced lower mental health problems after the face covering policy was introduced, but individuals without pre-existing mental health conditions experienced greater mental health improvements during the face covering phase.

In all three phases, those who never drank alcohol had higher anxiety and distress scores compared to those who reported alcohol consumption four or more times a week. Implementation of the face covering policy improved mental health scores of all groups of alcohol users. Users of drugs had higher anxiety and distress scores compared to 'never' users, but never users of drugs showed higher improvements in mental health scores during the face covering phase. Those who ever experienced suicidal thoughts had higher anxiety and distress scores compared to those who never had such thoughts. As with all other factors, improvements were noted when the face covering policy was introduced, but again, greater improvements are seen among the non-vulnerable group, those who never experienced suicidal thoughts.

Results from regression models

Table 4 shows the changes in mental health outcomes measured using GAD-7 and IES-R by two policy changes dates (July 4 and 24, 2020), and demographics, pre-existing health conditions, and lifestyles. For every group of demographics, pre-existing health conditions, and lifestyles, changes in anxiety and distress scores at two dates were estimated by running a simple OLS regression, which followed the specification of the interrupted time series model equation. The coefficients of two discontinuity dummies for two policy changes dates, which are estimates of changes in anxiety and distress scores at two dates, are shown in the Table 4. In each regression, linear function of trend variable (time) was considered, as Figures 2 and 3 did not suggest any non-linearity. To note that, in the regression of a group, all other covariates except one corresponding to that group were used. For example, in the regression of the male group, the only male dummy was dropped, but all other covariates defined by all

Table 4 Changes in mental health indices by cut-off dates, control variables from regression discontinuity design regression models

Policy change dates in 2020	Population sub-groups	GAD-7, changes (95%CI)	*P* value	IESR, changes (95%CI)	*P* value
July 4, 2020 (Lockdown relaxation date)	Total sample	-0.513 (-0.913, -0.112)	0.081	-2.620 (-4.279, -0. 961)	0.464
July 24, 2020 (Face-covering start date)	Total sample	-1.148 (-1.800, -0.496)		-3.449 (-5.725, -1.172)	
	Key worker				
July 4, 2020 (Lockdown relaxation date)	Not a key worker	-0.910 (-1.810, -0.011)	0.062	-3.546 (-6.235, -0.857)	0.708
	Health	0.017 (-0.602, 0.637)		-1.643 (-3.914, 0.628)	
	Non-health	-0.756 (-1.877, 0.365)		-1.704 (-5.115, 1.708)	
July 24, 2020 (Face-covering start date)	Not a key worker	-1.191 (-2.259, -0.123)	0.064	-3.877 (-7.410, -0.343)	0.843
	Health	-0.986 (-1.584, -0.387)		-1.693 (-4.376, 0.991)	
	Non-health	-1.421 (-3.454, 0.613)		-5.458 (-9.144, -1.772)	
	Gender				
July 4, 2020 (Lockdown relaxation date)	Female	-0.496 (-0.983, -0.010)	0.817	-2.606 (-4.445, -0.767)	0.936
	Male	-0.622 (-1.652, 0.409)		-2.461 (-5.929, 1.007)	
July 24, 2020 (Face-covering start date)	Female	-1.013 (-1.778, -0.248)	0.382	-3.369 (-5.789, -0.948)	0.926
	Male	-1.739 (-2.993, -0.485)		-3.112 (-6.985, 0.762)	
	Age group				
July 4, 2020 (Lockdown relaxation date)	Under 21	-5.482 (-9.526, -1.437)	0.029	-19.319 (-41.541, 2.902)	0.260
	21-24	-0.103 (-1.975, 1.770)		-3.715 (-8.350, 0.920)	
	25-34	-0.314 (-1.346, 0.717)		-2.653 (-4.900, -0.406)	
	35-44	-0.640 (-1.646, 0.366)		0.545 (-2.309, 3.399)	
	45-54	0.179 (-0.663, 1.021)		-1.871 (-4.785, 1.043)	
	55-64	-0.911 (-2.117, 0.294)		-5.390 (-9.419, -1.361)	
	65 and over	-0.923 (-2.330, 0.484)		-2.633 (-8.466, 3.199)	
July 24, 2020 (Face-covering start date)	Under 21	-0.983 (-5.502, 3.536)		-3.941 (-23.634, 15.753)	
	21-24	-0.830 (-6.322, 4.661)		-2.354 (-14.469, 9.761)	
	25-34	-1.928 (-3.272, -0.584)		-7.306 (-11.582, -3.029)	
	35-44	-0.722 (-2.406, 0.962)		-0.469 (-5.717, 4.780)	
	45-54	-0.641 (-1.940, 0.658)		-2.386 (-5.752, 0.980)	
	55-64	-0.997 (-1.971, -0.023)		-1.930 (-5.331, 1.472)	
	65 and over	-1.447 (-2.952, 0.057)	0.995	-4.192 (-9.646, 1.261)	0.795
	Ethnicity				
July 4, 2020 (Lockdown relaxation date)	Non-white	1.302 (0.085, 2.518)		3.185 (-2.139, 8.510)	
	White	-0.657 (-1.129, -0.185)	0.018	-3.044 (-4.830, -1.259)	0.035
July 24, 2020 (Face-covering start date)	Non-white	-0.104 (-1.715, 1.506)		-0.380 (-6.308, 5.548)	
	White	-1.243 (-1.957, -0.529)	0.348	-3.567 (-5.888, -1.246)	0.410
	Religion				

July 4, 2020 (Lockdown relaxation date)	Non-Christian	-0.369 (-0.934, 0.195)	0.522	-2.500 (-4.563, -0.437)	0.904
	Christian	-0.652 (-1.298, -0.006)		-2.679 (-4.909, -0.449)	
July 24, 2020 (Face-covering start date)	Non-Christian	-1.298 (-2.290, -0.306)	0.578	-3.473 (-6.483, -0.464)	0.957
	Christian	-0.928 (-1.630, -0.226)		-3.354 (-6.289, -0.420)	
	Education				
July 4, 2020 (Lockdown relaxation date)	A-level or less	-1.363 (-1.929, -0.797)	0.007	-3.958 (-6.641, -1.275)	0.221
	Higher degree	-0.080 (-0.512, 0.352)		-1.955 (-3.408, -0.502)	
July 24, 2020 (Face-covering start date)	A-level or less	-1.421 (-2.058, -0.783)	0.460	-4.109 (-6.780, -1.438)	0.561
	Higher degree	-0.876 (-1.712, -0.041)		-2.667 (-5.356, 0.022)	
	Accommodation				
July 4, 2020 (Lockdown relaxation date)	Rented	-0.369 (-1.449, 0.712)	0.796	-1.933 (-5.935, 2.068)	0.675
	Own	-0.517 (-0.919, -0.114)		-2.719 (-4.784, -0.653)	
July 24, 2020 (Face-covering start date)	Rented	-1.837 (-3.056, -0.618)	0.197	-4.387 (-9.165, 0.391)	0.571
	Own	-0.782 (-1.419, -0.144)		-2.820 (-4.892, -0.748)	
	Require shielding by government				
July 4, 2020 (Lockdown relaxation date)	Not required	-0.322 (-0.750, 0.107)	0.241	-2.212 (-3.717, -0.706)	0.560
	Required shielding, but not shielding	-1.243 (-2.295, -0.191)		-4.136 (-8.303, 0.032)	
	Required shielding and shielding	-0.655 (-2.023, 0.713)		-3.447 (-8.512, 1.619)	
July 24, 2020 (Face-covering start date)	Not required	-0.978 (-1.721, -0.234)	0.393	-3.175 (-5.683, -0.668)	0.956
	Require shielding, but not shielding	-1.045 (-2.351, 0.261)		-3.730 (-10.106, 2.647)	
	Require shielding and shielding	-3.064 (-4.686, -1.442)		-4.742 (-10.111, 0.628)	
	Experience of COVID-19				
July 4, 2020 (Lockdown relaxation date)	No	-0.559 (-1.279, 0.161)	0.892	-1.999 (-4.771, 0.774)	0.657
	Yes	-0.490 (-0.961, -0.018)		-2.795 (-4.666, -0.924)	
July 24, 2020 (Face-covering start date)	No	-1.927 (-2.904, -0.951)	0.156	-6.223 (-10.542, -1.905)	0.131
	Yes	-0.875 (-1.621, -0.129)		-2.462 (-4.509, -0.416)	
	Pre-existing mental health condition				
July 4, 2020 (Lockdown relaxation date)	No	-0.343 (-0.729, 0.043)	0.551	-2.308 (-3.782, -0.834)	0.788
	Yes	-0.649 (-1.582, 0.284)		-2.772 (-6.246, 0.702)	
July 24, 2020 (Face-covering start date)	No	-0.687 (-1.194, -0.181)	0.239	-1.407 (-3.154, 0.340)	0.056
	Yes	-1.576 (-3.163, 0.012)		-6.239 (-10.192, -2.286)	
	Drinking alcohol				
July 4, 2020 (Lockdown relaxation date)	Never	-1.025 (-2.463, 0.412)		-3.091 (-7.778, 1.596)	
	Monthly or less	-0.582 (-1.779, 0.615)		-3.020 (-6.621, 0.581)	

	2-4 times a month	-0.243 (-0.901, 0.415)		-2.017 (-4.434, 0.401)	
	2-3 times a week	-0.050 (-0.543, 0.443)		-1.782 (-3.882, 0.319)	
	4 times or more a week	-1.165 (-2.178, -0.151)	0.401	-3.784 (-7.229, -0.340)	0.828
July 24, 2020 (Face-covering start date)	Never	-1.309 (-3.955, 1.337)	0.835	2.636 (-2.839, 8.111)	0.607
	Monthly or less	-1.240 (-2.787, 0.306)		-2.619 (-5.693, 0.455)	
	2-4 times a month	-1.251 (-2.243, -0.259)		-6.981 (-10.394, -3.568)	
	2-3 times a week	-1.140 (-1.694, -0.587)		-4.444 (-7.173, -1.715)	
	4 times or more a week	-0.601 (-2.269, 1.067)		-1.616 (-6.815, 3.583)	
	Taking drugs				
July 4, 2020 (Lockdown relaxation date)	No	-0.504 (-0.890, -0.118)	0.542	-2.522 (-4.160, -0.883)	0.955
	Yes	0.631 (-3.023, 4.286)		-2.827 (-12.067, 6.412)	
July 24, 2020 (Face-covering start date)	No	-1.114 (-1.669, -0.558)	0.875	-3.571 (-5.538, -1.604)	0.222
	Yes	-1.470 (-6.338, 3.398)		5.805 (-11.429, 23.039)	
	Suicidal thoughts ever				
July 4, 2020 (Lockdown relaxation date)	No	-0.173 (-0.599, 0.252)	0.039	-0.941 (-2.482, 0.600)	0.003
	Yes	-1.232 (-1.983, -0.481)		-5.938 (-8.759, -3.118)	
July 24, 2020 (Face-covering start date)	No	-0.831 (-1.343, -0.319)	0.337	-2.520 (-4.065, -0.975)	0.511
	Yes	-1.588 (-3.487, 0.310)		-4.256 (-9.486, 0.974)	

Note: To capture the effects of lockdown easing and compulsory face-covering on different groups, separate OLS regressions were run for all demographics, lifestyle change type, and pre-existing health condition (listed above) using the Regression Discontinuity Design model. Cluster/date/trend adjusted 95% confidence intervals are in parentheses. *P* values are shown to indicate whether changes in mental health scores are different among those listed groups. CI: Confidence intervals; COVID-19: Coronavirus disease 2019; GAD-7: Generalised anxiety disorder-7; IES-R: Impact of events scale-revised.

other groups are used.

Compared to discontinuities seen in Figures 2 and 3, the smaller discontinuities in outcomes are due to controlling for the effects of a large set of individual risk factors. This should be obvious as the regressions control for individual risk factors. We have focused on mental health changes at the cut-off dates only, not the differences in the entire time span. Therefore, we do not rely on the results shown in Tables 2 and 3.

Overall, the coefficients suggest a statistically significant fall in both anxiety and distress scores at the two policy changes dates. The fall in GAD-7 score at the first and second cut-off dates was -0.513 (95%CI: -0.913, -0.112) and -1.148 (95%CI: -1.800, -0.496), respectively. The corresponding figures for IES-R were -2.620 (95%CI: -4.279, -0.961) and -3.449 (95%CI: -5.725, -1.172), respectively. These figures suggest that both anxiety and distress reduced when the lockdown relaxation and the face covering measures were introduced. The reductions in mental health scores were higher when the face covering policy was introduced compared to the start of the lockdown relaxation.

There was no statistically significant reduction in the GAD-7 (0.017, 95%CI: -0.602, 0.673) and IES-R scores (-1.643, 95%CI: -3.914, 0.628) for health workers and other key workers (GAD-7: -0.756, 95%CI: -1.877, 0.365; IES-R: -1.704, 95%CI: -5.115, 1.708) at the first cut-off date. However, for health workers, when face covering was introduced the GAD-7 score reduced significantly, although there was no significant change in their IES-R score. At the second cut-off date, other key workers had a significant reduction in IES-R (-5.458, 95%CI: -9.144, -1.772) but no statistically significant change in GAD-7 score (-1.421, 95%CI: -3.454, 0.613).

Anxiety and distress scores significantly reduced for both females (GAD-7: -0.496, 95%CI: -0.983, -0.010; IES-R: -2.606, 95%CI: -4.445, -0.767) and males (GAD-7: -0.622, 95%CI: -1.653, 0.409; IES-R: 2.461, 95%CI: -5.929, 1.007) at the first cut-off date and also at the second cut-off date (females: GAD-7: -1.013, 95%CI: -1.778, -0.248; IES-R: -3.369, 95%CI: -5.789, -0.948) (males: GAD-7: -1739, 95%CI: -2.993, -0.485; IES-R: -3.112, 95%CI:

-6.985, -0.762). At both dates, the fall in GAD-7 were higher among males compared to females. IES-R shows the opposite picture. Those below 21 years of age showed a statistically significant decline in GAD-7 (-5.482: 95%CI: -9.526, -1.437) at the first cut-off date compared to all other age groups. However, the reductions in mental health scores were not statistically significant in the below 21 years group when the face covering policy was introduced (GAD-7: -0.983, 95%CI: -5.502, 3.536).

People from white ethnic background had a significant reduction in GAD-7 (-0.657, 95%CI: -1.129, -0.185 at the first cut-off date; and -1.243, 95%CI: -1.957, -0.529 at the second cut-off date) and IES-R (-3.044, 95%CI: -4.830, -1.259 at the first cut-off date; -3.567, 95%CI: -5.888, -1.246 at the second cut-off date). There was no statistically significant change in the mental health status of non-white ethic population in the study.

Christians had a statistically significant fall in GAD-7 (-0.652, 95%CI: -1.298, -0.006 at the first cut-off date; -0.928, 95%CI: -1.630, -0.226 at the second cut-off date) and IES-R (-2.679, 95%CI: -4.909, -0.449 at the first cut-off date; -3.354, 95%CI: -6.289, -0.420 at the second cut-off date). At the first cut-off date, non-Christians had a significant decrease only in IES-R (-3.473, 95%CI: -6.483, -0.464). At the second cut-off date, non-Christians had a significant reduction in GAD-7 (-1.298, 95%CI: -2.290, -0.306) and IES-R: (-3.473, 95%CI: -6.483, -0.464).

There were significant reductions in the anxiety and distress scores of people with A-level or below and higher degree at both cut-off points. However, for higher degree holders, the improvements in mental health were seen only in IES-R (-1.955, 95%CI: -3.408, -0.502) at the first cut-off date and GAD-7 at the second cut-off date (-0.876, 95%CI: -1.712, -0.041). The lower educated group had a greater improvement in mental health at both cut-off dates.

People living in rented accommodation did not report improvements in their mental health at the first cut-off date (GAD-7: -0.369, 95%CI: -1.449, 0.712; IES-R: -1.933, 95%CI: -5.935, 2.068), but did report an improvement at the second cut-off date for GAD-7 only (-1.837, 95%CI: -3.056, -0.618). Those living in their own accommodation had statistically significant improvements in both GAD-7 and IES-R at both cut-off dates.

Those who were shielding did not report any improvements in their mental health at the first cut-off date (GAD-7: -0.655, 95%CI: -2.023, 0.713 and IES-R: -3.447, 95%CI: -8.512, 1.619). There was improvement in GAD-7 at the second cut-off date for this group. Those who were not shielding had no improvement in mental health, except for GAD-7 at the first cut-off date (-1.243, 95%CI: -2.295, -0.191).

Those who experienced COVID-19 illness reported an improvement in their mental health status at the first (GAD-7: -0.490, 95%CI: -0.961, -0.018) and second (GAD-7: -0.875, 95%CI: -1.621, -0.129) cut-off dates. Those who did not experience any such problems reported an improvement in their mental health at the second cut-off date only.

People who had previous mental health conditions did not experience statistically significant improvements in their mental health at the first cut-off date (GAD-7: -0.649 95%CI: -1.582, 0.284; IES-R: -2.772, 95%CI: -6.246, 0.702). At the second cut-off date, there was improvement for this group in IES-R (-6.239, 95%CI: -10.192, -2.286), but not in GAD-7. For those with no mental health issues, improvement in GAD-7 was noted at the second cut-off date.

Statistically significant improvement in mental health was seen at the first cut-off date among respondents who drank alcohol 4 or more times in a week (GAD-7: -1.165, 95%CI: -2.178, -0.151; IES-R: -3.784, 95%CI: -7.229, -0.340). At the second cut-off date, those who drank alcohol moderately had statistically significant improvement in the measured mental health indices. Those who were taking drugs did not experience an improvement in their mental health scores at the first (GAD-7: 0.631, 95%CI: -3.023, 4.286; IES-R: -2.827, 95%CI: -12.067, 6.412) or second cut-off dates (GAD-7: -1.470, 95%CI: -6.338, 3.398; IES-R: 5.805, 95%CI: -11.429, 23.039). However, at both cut-off dates, there were significant improvements in the mental health of those who did not take drugs.

Those who reported suicidal thoughts ever in their life showed improvements in their mental health at the first cut-off date (GAD-7: -1.232, 95%CI: -1.983, -0.481; IES-R: -5.938, 95%CI: -8.759, -3.118), but not at the second cut-off date (GAD-7: -1.588, 95%CI: -3.487, 0.310; IES-R: -4.256, 95%CI: -9.486, 0.974). However, those who had no suicidal thoughts had no improvements in their mental health at the first cut-off date (GAD-7: -0.173, 95%CI: -0.599, 0.252; IES-R: -0.941, 95%CI: -2.482, 0.600), but did improve at the second cut-off date (GAD-7: -0.831, 95%CI: -1.343, -0.319; IES-R: -2.520, 95%CI: -4.065, -0.975).

Robustness check

These results would be robust if the local randomization exists around the cut-off (policy changing) dates, meaning that individuals are randomly distributed around the cut-offs. If it can be shown that all control variables (*e.g.*, demographics, pre-existing health conditions, and lifestyles, which are dummy variables) are insignificantly discontinuous at those cut-off dates, it can be said that the local randomization exists around those cut-offs. In other words, insignificant discontinuities in control variables will guarantee that significant discontinuities in mental health scores (GAD-7 and IES-R) happen due only to policy changes (relaxation of lockdown and face-covering), not due to changes in the control variables, which also affect those mental health scores.

Separate OLS regressions of every control dummy following the same RDD specification in equation were run. The outcome variable was just replaced with the control dummy. Every dummy has a base category, for which the dummy variable is not needed; otherwise, there would be a dummy trap. For that reason, when the male dummy is used, for example, the female dummy is not needed, and Supplementary Table 1 does not show results for that reason. The coefficients of the discontinuity dummies for two cut-off dates, with 95%CI, are shown in Supplementary Table 1 in Supplementary material. As both GAD-7 and IES-R had different sizes of samples, two groups of such regressions of control variables were run using two different common samples of GAD-7 and IES-R. Common samples come from the regressions of those mental health scores. Results in Supplementary Table 1 imply that most of the control dummies are insignificantly discontinuous, implying that the main results in Table 4 are mostly robust.

Other biases (caused by unobserved factors', changes or any other policy changes that affect mental health outcomes) can be captured by checking discontinuities in the density of the assignment/trend variable. We found this was statistically insignificant (not shown). There were no other national policy changes at exactly those cut-off dates. From the visual inspection of Figures 2 and 3, there were no clear discontinuities in mental health outcomes at any other dates. If discontinuities in mental health outcomes at the policy changing cutoff dates were random events, there would have been such discontinuities at other dates. This informal falsification test also implies that our results capture mostly causal effects.

Limitations

A key limitation of this study is a high number of missing cases and non-random selection of participants. However, the methodology used in this study mitigates against this limitation by comparing matching cases before and after each policy intervention. Identification tests imply that local randomization exists around the cut-off dates, implying that the findings are robust.

Another limitation is the non-probability sample design and time limited survey which means longitudinal changes were not possible to elicit. Similarly, pre pandemic data was not available, although this was not possible for this survey which was not designed pre pandemic. However, the results from phase one will be compared to phase two of the survey that was conducted from November 20, 2020 to February 2021.

DISCUSSION

This paper examined the association of the lockdown relaxation and the implementation of the face covering policy on the mental health of the general population and sub-groups in the United Kingdom using interrupted time series model. Mental health status was measured using two standardised mental health measures, GAD-7 and IES-R.

This study in the United Kingdom reports a casual association of lockdown on mental health of the participants. The findings compare with similar research carried out in the United Kingdom which showed "minimal" impact of lockdown on the mental health of the general population[1,8,9]. One of the reasons for "mild" anxiety and distress in the United Kingdom during lockdown may be because of several economic and welfare government policies.

This study confirms improvements in anxiety and distress levels following lockdown relaxations. Relaxation of lockdown started on July 4, 2020 in the United Kingdom and showed significant improvements in the population's mental health conditions. However, much greater improvement in anxiety and distress was observed

when face covering in public places was enforced on July 24, 2020. It appears that face covering provided confidence in protection from the virus while visiting friends, public places, clinics, shops and other such places. It may be noted here that when lockdown relaxations were implemented on July 4, 2020, face covering use in the United Kingdom was very limited. Face covering implementation in public places had a significant positive association with mental health on all population sub-groups, suggesting wider benefit of the face covering policy on mental health.

This study identified significantly higher levels of anxiety and distress among people with pre-existing mental health issues, those who were shielding, those who reported suicidal thoughts, drug and alcohol use, and experience of episodes of COVID-19 illness. These population sub-groups benefited by both lockdown relaxation and face covering policy. However, face covering had a greater association with improvement in anxiety and distress than lockdown relaxation.

Higher levels of anxiety and distress among females and younger age groups were noted in this study, which is similar to the emerging global evidence[20]. The findings also compare to other studies that have reported differential impact of COVID-19 Lockdown restrictions on mental health by predisposing health conditions and socio-demographic characteristics. An international study carried out by CARE in 40 countries showed that 27% of women reported an increase in challenges associated with mental illness compared to only 10% of men[20]. A study carried out in Tunisia showed anxiety, depressive symptoms, and stress were found in about 85% of women [21]. Other studies also reported experience of higher mental health problems among females compared to males[6]. A meta-analysis of 206 studies showed minimal differences in the prevalence of mental health issues such as anxiety, depression, and PTSD among healthcare professionals and the public during the pandemic. A new development in this study was that there appears to be higher prevalence of suicidal thoughts/ideation or self-harm (11% *vs* 5.8%) and lower prevalence of wellbeing (28.2% *vs* 52.6%) among the public compared to healthcare professionals which had previously not been reported[22]. Globally there is evidence of domestic violence and more workload for women than men during lockdown[23-26]. There is evidence of lower participation of women in COVID-19 related policy committees[27].

Similar to findings from this study, there is evidence from various studies that the younger age groups had higher levels of mental health problems during lockdown restrictions compared to older age groups[6]. However, older adults have shown lower sleeping quality during the pandemic period compared to the pre-pandemic period[28].

Health workers, particularly frontline staff, played an important role during the pandemic. At the beginning of the pandemic, there is evidence of increased mental health impact on health workers. For example, at the time of COVID-19 in China and Japan, depression, anxiety, insomnia and resilience were higher among frontline health workers than the general population[29,30]. The prevalence of depression, anxiety, and stress has been shown to have remained elevated even after the restrictions were lifted in a study in Malaysia[31]. In this study, anxiety and stress levels of health workers were lower than other key workers. The reason for low levels of anxiety and stress among health workers is currently less understood and a probable reason could be their professional attitude and support from the general public for the important work they do for the country. One can also hypothesise that the health workers learned self-help stress-management and mindfulness that they prescribed to their patients[32]. Studies have also reported increased mental health problems in those who had chronic/psychiatric illnesses, unemployment, student status, and frequent exposure to social media/news concerning COVID-19, compared to their counterparts[6,33]. Living alone during the lockdown, a longer duration of illness, and smoking habits had higher associations with COVID-19 related distress [34]. Detachment, pre-existing mental health problems, fewer coping strategies and childlessness were associated with higher levels of depression and stress[35]. Our study shows similar findings, thereby endorsing the evidence base of the impact of the pandemic.

CONCLUSION

In conclusion, evidence is building on the differential psychological impact of the pandemic, resultant restrictions and policies, based on socio-demographic variables, pre-existing vulnerabilities and health care worker status that will help future planning and policies. Such evidence when used collectively should inform future

planning for pandemics and develop collective and individual physical and mental resilience.

ARTICLE HIGHLIGHTS

Research background

The global pandemic caused by coronavirus disease 2019 has led to wide spread changes in people's day to day lives.

Research motivation

The changes in people's lives and livelihoods due to the global pandemic, associated lockdowns and government guidance is anticipated to have a great impact on people's emotional and social wellbeing.

Research objectives

Positive association of lockdown relaxation and face covering policies on the Mental Health of various population sub-groups is reported.

Research methods

A regression discontinuity design was used to analyse data gathered on people's health and wellbeing during different time periods and restrictions *via* online survey platform.

Research results

In comparison to other key workers and non-key workers during lock down, professional groups and health workers had lower generalised anxiety disorder (GAD-7) scores indicating lower anxiety levels. Similar findings were noted for the impact of events scale-revised (IES-R) scores with health workers, indicating lower levels of distress. During the compulsory face covering phase, there were improvements in mental health scores for all three professional groups assessed by GAD-7 and IES-R. Greater improvements in mental health scores were found among non-key workers than key workers. Gender was associated with different mental health outcomes during the lockdown, with females scoring higher on the GAD-7 and IES-R scales in comparison to males. However, both groups showed a significant improvement in mental health status during the period of face covering, with slightly higher improvements noted in males.

Research conclusions

An impact on people's wellbeing was found, with anxiety and depression levels improving when relaxations in restrictions happened.

Research perspectives

Further investigation into pandemic preparedness for those with pre-existing conditions such as anxiety, depression or obsessive-compulsive disorders and modifying psychological interventions in this population is warranted.

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