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Effects of Lockdown Restrictions and Impact of Anxiety and Depression Symptoms in People With Chronic Pain During the Covid-19 Pandemic: A 13-Wave Longitudinal Study

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Abstract: In early 2020, countries across the world imposed lockdown restrictions to curb the spread of the Covid-19 coronavirus. Lockdown conditions, including social and physical distancing measures and recommended self-isolation for clinically vulnerable groups, were proposed to disproportionately affect those living with chronic pain, who already report reduced access to social support and increased isolation. Yet, empirical evidence from longitudinal studies tracking the effects of prolonged and fluctuating lockdown conditions, and potential psychological factors mediating the effects of such restrictions on outcomes in chronic pain populations, is lacking. Accordingly, in the present 13-wave longitudinal study, we surveyed pain intensity, pain interference, and tiredness in people with chronic pain over the course of 11 months of the Covid-19 pandemic (April 2020–March 2021). Of $N = 431$ participants at baseline, average completion rate was ~50% of time points, and all available data points were included in linear mixed models. We examined the impact of varying levels of lockdown restrictions on these outcomes and investigated whether psychological distress levels mediated effects. We found that a full national lockdown was related to greater pain intensity, and these effects were partially mediated by depressive symptoms. No effects of lockdown level were found for pain interference and tiredness, which were instead predicted by higher levels of depression, anxiety, pain catastrophising, and reduced exercise. Our findings are relevant for improving patient care in current and future crises. Offering remote management options for low mood could be particularly beneficial for this vulnerable population in the event of future implementation of lockdown restrictions.

Perspective:* *This longitudinal study demonstrates the impact of Covid-19 lockdown restrictions on people with chronic pain. Findings suggest a complex interaction of psychosocial factors that impacted various aspects of pain experience in patients, which offer the potential to inform clinical strategies for remote medicine and future crises.

Key words: *Coronavirus, Tiredness, Isolation, Pain interference, Excercise*

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In March 2020, the government of the United Kingdom (UK) imposed strict national lockdown restrictions to curb the spread of a new type of coronavirus (Covid-19). Members of the public were instructed to stay at home (unless classed as essential workers) and to severely limit social contact and outdoor exercise. Access to healthcare was impacted, with restricted access to services, a reduction in face-to-face appointments, and routine surgeries suspended.[1,2] Patients with chronic illnesses were more heavily impacted by cancellations and reductions in healthcare provision compared to other service users.[3] Telemedicine programs provided useful benefits for patients throughout the pandemic,[4] but cannot wholly replace requirements, for example, for a physical examination.[5] Overall, these changes to daily living, access to healthcare services, and treatment delivery were proposed to substantially, and disproportionately, affect vulnerable patients living with long-term conditions, such as chronic pain.[6–9]

Although individual studies reported elevated levels of anxiety and depression across the pandemic,[10] a meta-analysis of studies in the general (pain-free) population found no effects of Covid-19 lockdown restrictions on general distress and negative affect, and only small effects on anxiety and depression symptoms.[11] However, people with chronic pain experienced initial lockdown restrictions differently to the general population. In a cross-sectional study conducted in April 2020, people with chronic pain reported increases in levels of pain severity during the first, most stringent period of lockdown compared to the period before the first lockdown[12] (see also ref.[13] for similar findings in the United States). People with chronic pain were also more adversely affected by initial lockdown conditions than pain-free individuals, reporting greater increases in anxiety and depressed mood, increased loneliness, and reduced levels of physical exercise.

Apart from higher baseline levels of distress, the intersectionality of chronic pain and factors including ethnicity and socioeconomic status were established to be associated with poorer prognosis and greater likelihood of long-term disability in response to contracting Covid-19.[14,15] Some individuals with chronic pain were classed as clinically extremely vulnerable and were advised to shield. In April 2020, UK residents with chronic pain were more likely to be self-isolating due to high-risk status, observing restrictions on activity and increased levels of social distancing over and above the stringent government-mandated lockdown restrictions.[12] People with chronic pain already experience reduced access to support and increased isolation[2] due to symptoms such as fatigue and loss of functioning, which may limit social interaction and reduce social network size (see ref.[9]). Shielding may have further exacerbated social isolation and loneliness, which are linked to heightened psychological distress, pain, and tiredness.[16]

More generally, lockdown restrictions have been conceptualised as a major life stressor.[17] As well as social isolation, lack of access to healthcare services, and financial uncertainty were experienced during the pandemic in a manner unprecedented in living memory.[18] In people with chronic pain, high levels of psychological distress were associated with negative emotions towards the pandemic and greater overall stress, and stress was related to a higher likelihood of reporting worsened pain[19]; see also ref.[20]

Given these largely cross-sectional and short-term findings, in the present paper, we focused on psychological variables and tracked levels of low mood, anxiety, and additionally pain catastrophising longitudinally through differing lockdown conditions. We also examined the impact of lockdown conditions themselves. UK lockdown measures were periodically relaxed and tightened across 2020 and 2021, and therefore we were able to directly compare effects of full national lockdown and eased restrictions on pain-related outcomes of pain intensity, tiredness, and pain interference in daily life. We surveyed people with chronic pain in the UK across an 11-month period from April 2020 to March 2021, asking them to report on key symptoms at 13 separate time points. We expected that more restrictive lockdown conditions would be linked to greater pain intensity, pain interference, and tiredness. Furthermore, we hypothesised that such effects would partially be mediated by elevated psychological distress, that is, that full lockdown would worsen low mood, anxiety, and catastrophising, and this psychological distress would, in turn, predict pain-related outcomes. Although we focused on psychological factors, we also accounted for some external factors, measuring individuals' levels of exercise, and individualised regional climate variables, which have been associated with pain flare-ups and mood.[21]

Methods

Design

This study used a longitudinal survey design. Across 13 time points between April 2020 and March 2021, participants with chronic pain rated their pain intensity and tiredness in the previous week, and completed validated self-report questionnaires assessing pain interference, pain catastrophising, and anxiety and depression symptoms. They also provided information regarding how much exercise they had done in the previous week. Using participants' location, we further coded level of lockdown at each point of survey completion, and obtained data on climate variables (number of daylight hours, mean temperature, and rainfall) in participants' region of residence in each month of survey completion. Our outcomes were pain intensity, pain interference, and tiredness. Our predictor of interest was the restrictiveness of lockdown conditions. Climate variables and exercise were considered as covariates, and we explored the role of the psychological variables in mediating the effects of lockdown on pain-related outcomes. The study was approved by the

Table 1. Demographic Characteristics at Baseline (April–May 2020)

		Chronic pain (N = 431)
Sex (F/M/other)		391/36/4
Age (years)		43.48 (13.50)
Geographical location	Northern Scotland	2
	Eastern Scotland	6
	Western Scotland	13
	Northern Ireland	0
	Republic of Ireland	0
	North West England and North Wales	241
	England East and North West	16
	Midlands	37
	East Anglia	5
	England South East and South	69
	South West England and South Wales	22
	Missing	20
Number people in household*	0	56
	1	143
	2	96
	3	97
	4	28
	>4	10
% isolating due to high-risk status at time point 1†		40.52
Taking opioids (subsample)‡	Yes	153
	No	153
	Prefer not to say	6

*Refers to number of other people in household. Information missing for *n* = 11 participants.
†Information missing for *n* = 9 participants.
‡Information missing for *n* = 119 participants.

University of Liverpool Research Ethics, Health and Life Sciences Committee.

Participants

N = 519 participants took part in the first data collection point of this longitudinal study. Of these participants, *n* = 431 had a chronic pain condition, while *n* = 88 were pain-free individuals (age-matched healthy comparison group, not included in this paper). Participants were recruited online via advertisements on social media (Facebook; Twitter) and online chronic pain support groups, and a subgroup of chronic pain patients (*n* = 85) was recruited through a local tertiary (specialist) pain clinic. Inclusion criteria specified respondents must be over the age of 18, fluent in English, and currently resident in the United Kingdom. For the chronic pain sample, a further inclusion criterion was a self-reported diagnosis of chronic pain for a minimum of 3 months. Given the small number of participants recruited from the clinic, we did not compare participants by method of recruitment. Baseline comparisons between chronic pain and healthy comparison groups (data collected April–May 2020) were reported in Fallon et al.[12]); the current paper focuses on follow-up data from the chronic pain group only obtained over 12 further time points from May 2020 to March 2021. Baseline demographic characteristics specific to the focus of this paper are presented in Table 1. We did not ask about race, ethnicity, socioeconomic status, level of education, or employment status. Types of chronic pain diagnoses are presented in detail in Fallon et al.[12]); briefly, the majority of participants with chronic pain reported chronic primary/secondary musculoskeletal pain (*n* = 174) or chronic widespread pain (*n* = 150) or chronic neuropathic pain (*n* = 51). There was attrition over the course of the longitudinal study; 28% of the original sample completed the 13th time point (see Table 2 for *n* at each time point). The mean number of completed time points was *M* = 6.45 (*SD* = 3.90); 45% completed 7 or more time points (ie, more than half the study), 24% completed 10 or more time points, and 10% completed all time points. All available data was included under the assumption that data was missing at random (see *Plan of Data Analysis*). A total of 2,764 data points were included for the pain intensity outcome, 2,768 for pain interference, and 2,785 for tiredness.

Materials and Measures

Outcome Measures

Pain intensity. At each time point, participants rated their level of pain intensity in the previous week on a 0 to 100 visual analogue scale (VAS) with the anchors "*no pain at all*" to "*extremely severe pain*". They also completed a pain differential scale (rating their pain relative to a typical week before the Covid-19 pandemic), which is not reported here.

Pain interference. At each time point, participants completed an adapted version of the Brief Pain Inventory (BPI) short form.[22] The BPI short form measures pain severity and its impact on functioning (ie, interference) in relation to the past 24 hours. We presented only the pain

Table 2. Mean (SD) Number of Weeks Since Start of the Study, Local Level of Lockdown, Daylight Hours, Monthly Temperature, Monthly Rainfall, Self-Report Measures, and Total Number of Participants Per Time point

	Time point												
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
N	*431*	*317*	*294*	*283*	*277*	*307*	*137*	*141*	*122*	*126*	*122*	*107*	*122*
Number weeks since start of study	1.75 (1.02)	3.94 (1.16)	5.93 (1.1)	7.85 (1.19)	9.91 (1.12)	12.12 (1.15)	16.93 (.76)	22.76 (1.01)	26.41 (1.19)	31.25 (.54)	35.08 (.61)	39.27 (.46)	44.48 (1.21)
Lockdown level	5 (0)	5 (0)	5 (0)	5 (0)	4.44 (1.38)	1.94 (1.69)	1.36 (.98)	2.08 (1.42)	3.22 (.86)	4.86 (.49)	3.33 (.54)	5 (0)	4.95 (.22)
Daylight hours	15.12 (1.01)	16.16 (.15)	16.52 (.52)	17.17 (.33)	17.08 (.26)	16.75 (.23)	14.82 (.26)	12.47 (.67)	10.28 (.52)	8.34 (.17)	7.25 (.08)	7.87 (.16)	10.20 (1.03)
Monthly temperature* in °C	10.69 (1.23)	11.76 (.84)	12.7 (1.45)	14.38 (1.01)	14.56 (.89)	14.7 (1.05)	16.33 (1.22)	12.71 (1.29)	9.65 (.83)	7.99 (.68)	4.5 (.56)	2.69 (.57)	5.06 (.98)
Monthly rainfall* in mm	24.1 (12.29)	18.69 (19.54)	54.24 (55.72)	112.57 (39.81)	115.24 (38.27)	113.68 (43.23)	158.43 (39.78)	80.96 (37.33)	189.68 (32.52)	122.61 (39.99)	175.31 (32.54)	177.17 (35.84)	113.21 (33.65)
Pain intensity	66.64 (17.93)	67.89 (19.16)	67.02 (20.3)	67.1 (21.8)	65.53 (23.84)	65.76 (22.9)	65.69 (21.96)	64.06 (22.71)	66.98 (22.96)	67.74 (23.53)	68.2 (23.33)	68.9 (20.75)	66.1 (23.26)
Pain interference (BPI)	6.28 (2.28)	5.99 (2.43)	6.23 (2.45)	6.17 (2.49)	5.94 (2.63)	6.24 (2.59)	5.93 (2.55)	6.00 (2.58)	6.31 (2.6)	6.37 (2.57)	6.59 (2.57)	6.50 (2.55)	6.21 (2.53)
Tiredness	75.26 (21.04)	74.96 (22.07)	76.91 (20.27)	78.19 (19.85)	75.62 (22.04)	76.53 (21.87)	76.3 (21.9)	73.57 (22.27)	77.31 (22.51)	75.46 (23.51)	79.53 (21.43)	77.86 (23.42)	74.64 (25.1)
Depression (HADS-D)	9.77 (4.42)	6.86 (3.85)	7.19 (4.3)	7.03 (4.08)	7.23 (4.27)	7.09 (4.26)	5.47 (3.53)	6.36 (4.07)	7.06 (4.48)	6.84 (4.37)	7.27 (4.73)	7.67 (5.02)	7.04 (4.71)
Anxiety (HADS-A)	11.45 (4.54)	8.43 (3.42)	8.24 (3.48)	8.4 (3.44)	8.26 (3.57)	8.32 (3.49)	7.26 (3.93)	7.43 (4)	7.74 (4.04)	7.83 (4)	7.71 (4.24)	7.29 (3.68)	7.21 (4.04)
Pain catastrophising (PCS)	25.5 (13.12)	24.69 (12.17)	24.72 (12.74)	24.73 (12.85)	24.5 (12.97)	24.46 (13.14)	23.75 (12.23)	23.13 (13.57)	23.74 (14.12)	24.17 (13.74)	25.54 (14.06)	24.1 (14.45)	23.86 (13.83)
Exercise	64.35 (28.02)	63.4 (25.61)	62.71 (25.85)	63.8 (25.6)	61.88 (27.37)	63.51 (25.93)	60.26 (26.32)	57.23 (24.83)	62.73 (24.09)	66.94 (23.36)	64.4 (27.28)	63.36 (27.18)	61.59 (26.22)

*Data collapsed across regions.

interference items, which ask about how much pain has interfered with seven domains (items), including walking, work, and social relationships. These seven items are rated on scales from 0 ("*does not interfere*") to 10 ("*completely interferes*"), with higher average scores denoting greater pain interference. Cronbach's alpha for pain interference at baseline was α = .95.

Tiredness. As for pain intensity, participants rated their level of tiredness in the previous week with anchors "*not at all*" to "*extremely tired*" on a 0 to 100 VAS at each time point.

Covariates

Climate variables. At each time point, we obtained data on three climate variables, as weather conditions have been linked to pain experience and mood.[21] First, we obtained the number of daylight hours for each participant in the month in which they completed each time point from the Met Office UK (https://www.metoffice.gov.uk/). Second, using participants' post codes at baseline, we also coded mean temperature and rainfall for each participant in the month in which they completed each time point using data for 11 regions specified by the Met Office (see Table 1 for number of participants per region). Data (across regions) at each time point are presented in Table 2. Daylight hours and temperature were highly correlated, hence the two variables were combined (sum of standardised values so that they would contribute equally) for use in analyses. The resulting combined variable was correlated with both temperature and daylight ($r = .96$, $p < .0001$).

Exercise. At each time point, participants completed differential scales indicating their perceived change (relative to a typical week before the Covid-19 pandemic) for levels of exercise over the past seven days.

Mediators

Anxiety and depression symptoms. Participants completed the Hospital Anxiety and Depression Scale (HADS[23]). The HADS is a commonly used 14-item self-report scale assessing anxiety and depression on two subscales. Seven items assessing anxiety (e.g., "*I feel tense or 'wound up'*") and seven items assessing depression (e.g., "*I feel as if I am slowed down*") were rated on scales from 0 to 3 and summed independently to yield scores for anxiety and depression. Higher scores indicated greater levels of anxiety and depression. Cronbach's alphas in the present sample (baseline) were α = .85 for anxiety and α = .82 for depression. In addition, participants completed differential scales indicating their perceived change (relative to a typical week before the Covid-19 pandemic) for anxiety and low mood over the past seven days, but we did not use these differential scales in analyses.

Pain catastrophising. Participants completed the 13-item pain catastrophising scale.[24] Items such as "I anxiously want the pain to go away" are rated on a scale from 0 (not at all) to 4 (all the time) and summed to create a total score, with higher scores denoting greater pain catastrophising. Cronbach's alpha in the present sample (at baseline) was α = .96.

Predictors of Interest

Lockdown level. We coded level of government-mandated lockdown for each participant at the time at which they completed each time point. Three national lockdowns were imposed in the United Kingdom between March 2020 and March 2021 (see ref.[25] for lockdown laws in England). The first national lockdown in the United Kingdom began on March 23, 2020. People were ordered to stay at home and were only permitted to leave the house to buy food or attend medical appointments; schools and 'non-essential' businesses were closed. No mixing of households was allowed. As the first lockdown was slowly relaxed, people were permitted to leave the house for 'outdoor recreation' and by June 2020, schools gradually re-opened, and people were permitted to meet others outside in groups of up to six people.

Lockdown codes evolved across the subsequent pandemic (with different tiers signalling different levels of lockdown at different points) and regional lockdowns were introduced in Summer 2020. We used participants' post codes and coded lockdown level by consulting national guidelines and local lockdown restrictions in England, Scotland and Wales.[26–28] Lockdown level was coded on the following 5-point scale: Lockdown level was rated as "*1*" if hardly any restrictions were imposed/restrictions were eased (UK tier was labelled 1 in a 4-tier system); "*2*" if restrictions were medium (tier labelled 2 or 1 depending on current tier system[27]); "*3*" if restrictions were high (labelled 3 or 2, depending on tier system that is, whichever was second highest in the current tier system); "*4*" if restrictions were very high (labelled 4 or tier 3 depending on tier system in use that is, whichever highest in tier system) or local lockdown imposed; and "*5*" if a full national lockdown was in place.

The first national lockdown was coded as 5 until July 4, 2020 as, although some minor easing occurred before then, this was comparable to the 2nd and 3rd national lockdowns. For example, in 2nd and 3rd national lockdowns, 'support bubbles' were introduced, but people were not allowed to meet people outside their bubble indoors, and non-essential businesses remained closed. The mean lockdown level for each time point is presented in Table 2.

Procedure

Participants were invited to take part in a longitudinal research study on the impact of Covid-19-related lockdown and isolation on chronic pain experience. On accessing the study link in the survey platform Qualtrics (Qualtrics, UT), participants first read the information sheet, gave informed consent, and then answered demographic questions, including whether or not they had a chronic pain condition and giving details regarding their diagnosis if applicable. Thereafter, participants completed the visual analogue scales followed by the validated questionnaires.

After the first data collection point, participants were sent links to complete five follow-up sessions every two weeks over a period of three months (time points 2–6), followed by seven further follow-up sessions every four weeks over a subsequent period of eight months. Days between time points varied slightly between participants, and so we computed time in weeks since the first data point was recorded from the first participant and used this continuous variable instead of fixed time point in the analyses (see Table 2).

Apart from the demographic information, including self-isolation status, which was only collected at time point 1, the survey contained the same visual analogue scales and measures outlined above at each time point.

Every participant was offered reimbursement of £3.33 for completing each session, which was paid upon completion of the first five follow-up sessions (maximum total £20). Participants were not reimbursed for the further seven follow-up sessions.

Plan of Data Analysis

Data were summarised in Stata 16[29] and statistical analyses were carried out in MATLAB (Version r2022a), and R (Version 4.1.3).

We ran linear mixed models with maximum likelihood estimation separately for our three outcomes of interest: pain intensity, pain interference, and tiredness. Linear mixed models are suitable for considering both fixed and random effects and are robust to missing data values (assuming data are missing at random) for participants who completed some (but not all) time points; thus, all available data from all participants was included. $N = 6$ participants completed two time points on the same day and their data for those points were excluded from analyses.

For each outcome, we ran a series of models. The critical p value was set to .05 and we conducted likelihood ratio tests to assess whether adding predictors significantly improved model fit. In each model, participant ID was included as a random effect. In the first step, we estimated the effect of lockdown (five levels) as a fixed effect only, based on a likelihood ratio test confirming that including it as a random effect did not improve the model. In the second step, we controlled for climate variables. Both fixed and random effects were included for climate (and all other predictors in subsequent models) since they were found to improve model fit. If lockdown was significant, we then included possible psychological mediators, namely anxiety (HADS-A), depression (HADS-D), and pain catastrophising, in their own step (Step 3) and added exercise in Step 4. If lockdown was non-significant, we considered psychological variables and exercise together in the same Step 3 and did not include a 4th step.

To examine whether effects of lockdown on pain-related outcomes were mediated by psychological distress, controlling for climate variables, we simplified the lockdown variable and included only two levels (lockdown level 1 vs 5) as a fixed effect only, as only this contrast was significant in the linear mixed models. Significant indirect effects and non-significant residual direct effects were taken as evidence for mediation and the proportion of the effect mediated (indirect divided by total effect) was calculated.

Results

Descriptive statistics for self-report measures are presented in Table 2. Most variables remained relatively stable, with only small fluctuations across the time points (see Fig 1). Pain interference scores (BPI, ranging from 5.93–6.59 across time points) were slightly lower compared to normative data obtained from a large sample of people with chronic pain in Australia and New Zealand (BPI interference average = 7).[30] HADS-D and HADS-A scores generally fell within the mild range.

Pain Intensity

Unstandardised model results (fixed effects) are presented in Table 3. In the first step, the effect of lockdown was significant for the full national lockdown (level 5) vs no lockdown restrictions (level 1) contrast: pain intensity was higher during full national lockdown. Adding the climate variables in Step 2 improved the model (see Table 4), despite climate predictors themselves not being significant. In Step 3, depression and pain catastrophising—but not anxiety—were significant predictors, with greater depressive symptoms and levels of pain catastrophising linked to greater pain intensity. Notably, the effect of full national lockdown was no longer significant after controlling for these psychological variables, suggesting their potential role as mediators in the lockdown effect. In the final step, exercise was a significant predictor, with greater reductions in exercise associated with greater pain intensity.

We then examined whether psychological distress mediated effects of lockdown level on pain intensity. For depression, the indirect effect was statistically significant (unstandardised estimate = .24, 95% CIs = .15–.34, $p < .001$) and the direct effect of lockdown was non-significant (unstandardised estimate = .29, 95% CIs = −.11 to .67, $p = .180$), indicating evidence of mediation (see Fig 2). The total unstandardised effect was .53 (95% CIs = .13–.91, $p = .01$) and the proportion mediated was .44 (95% CIs = .23–1.69, $p = .01$). For pain catastrophising, the indirect effect was non-significant (unstandardised estimate = .07, 95% CIs = −.03 to .18, $p = .162$) while the direct effect was significant (unstandardised estimate = .43, 95% CIs = .06–.81, $p = .026$).

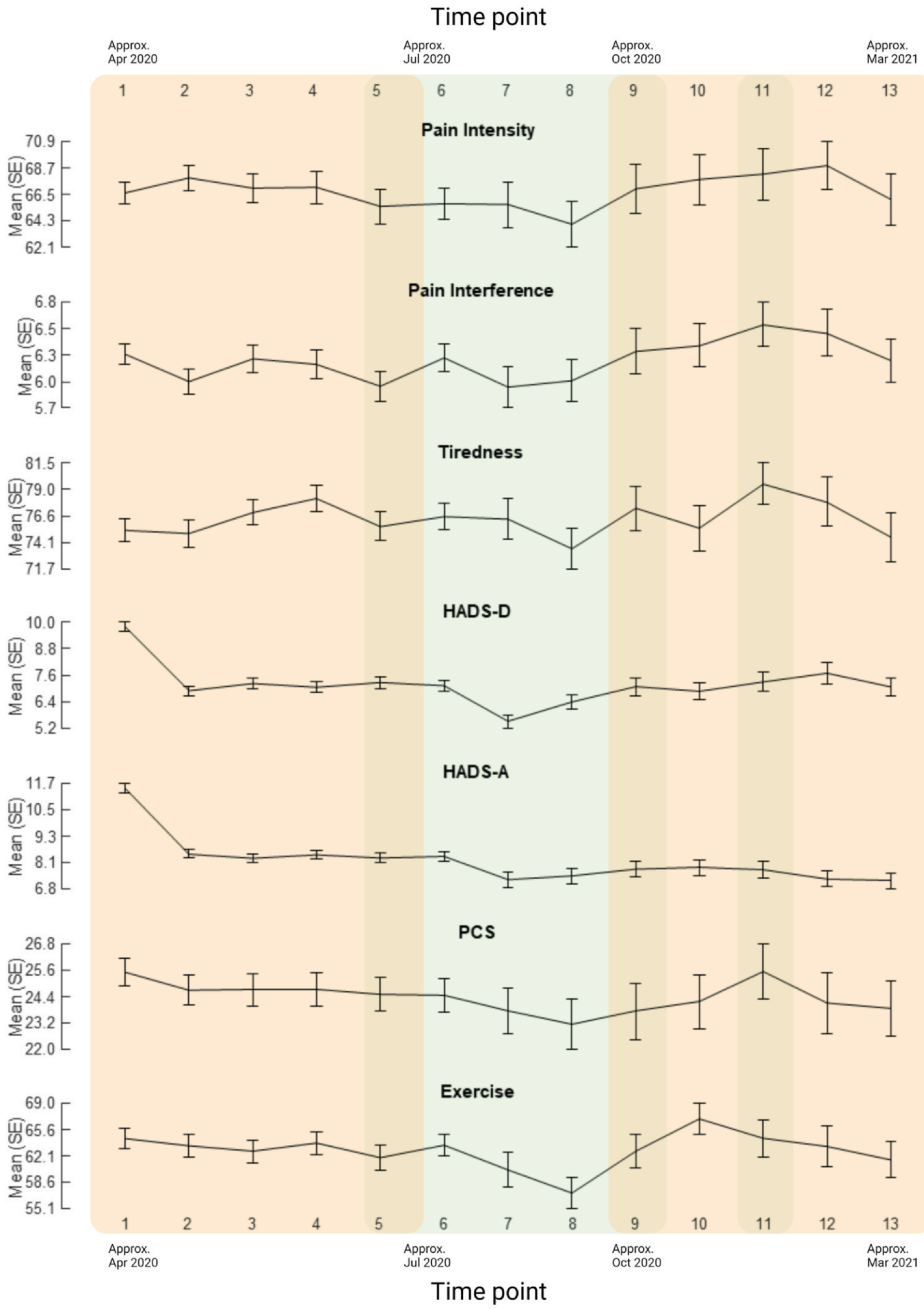

Figure 1. Mean scores for pain intensity, pain interference, tiredness outcomes, depression (HADS-D), anxiety (HADS-A), pain catastrophising (PCS), and exercise across the 13 time points. Error bars denote ± 1 SE of the mean. Orange shading denotes full national lockdown, green shading denotes easing, overlapping shading indicates a mixture of lockdown restrictions depending on the exact date at which participants completed the survey and local variations in lockdown restrictions.

Thus, depression but not pain catastrophising partially mediated effects of lockdown on pain intensity.

Pain Interference and Tiredness

Model results (fixed effects) are presented in Table 5. Model fit was significantly improved at each step (see Table 4). At Step 1, lockdown level did not predict pain interference in any of the models. At Step 2, rainfall was a significant predictor in the tiredness model, with more rainfall linked to greater tiredness. Finally, at Step 3, depression, anxiety, pain catastrophising, and exercise were all significant predictors, with greater depression, anxiety, and pain catastrophising levels, and reduced exercise linked to greater pain interference and tiredness. As there were no significant effects of lockdown, we did not carry out any mediation analyses.

In sum, full national lockdown predicted higher pain intensity, and effects were partially mediated by depression levels. For pain interference and tiredness, there was no significant impact of lockdown, but greater depression, anxiety, pain catastrophising, and reduced

Table 3. Model Results for the Pain Intensity Outcome

Model	Name	Unstandardised estimate	SE	p	95% CI lower	95% CI upper
1	Intercept	65.11	1.05	< .001	63.04	67.17
	Lockdown level 2	1.73	2.74	.527	-3.63	7.1
	Lockdown level 3	1.4	1.44	.331	-1.42	4.23
	Lockdown level 4	-.91	1.38	.504	-3.62	1.78
	Lockdown level 5	**1.59**	**.75**	**.034**	**.12**	**3.07**
2	Intercept	64.32	1.17	< .001	62.04	66.61
	Lockdown level 2	2.47	2.82	.383	-3.07	8
	Lockdown level 3	1.73	1.63	.289	-1.47	4.93
	Lockdown level 4	-.58	1.42	.684	-3.36	2.21
	Lockdown level 5	**2.04**	**.80**	**.011**	**.47**	**3.6**
	Rain	.004	.01	.460	-.01	.02
	Daylight and Temperature	.09	.2	.657	-.31	.5
3	Intercept	45.35	1.73	< .001	41.95	48.74
	Lockdown level 2	3.05	2.71	.261	-2.27	8.36
	Lockdown level 3	1.47	1.56	.346	-1.59	4.53
	Lockdown level 4	-1.55	1.37	.258	-4.24	1.14
	Lockdown level 5	1.15	.77	.138	-.37	2.67
	Rain	.01	.01	.147	-.003	.02
	Daylight and Temperature	.23	.19	.217	-.14	.60
	HADS-D	**.59**	**.11**	**< .001**	**.38**	**.80**
	HADS-A	.02	.12	.888	-.21	.24
	PCS	**.61**	**.05**	**< .001**	**.52**	**.70**
4	Intercept	41.85	1.89	< .001	38.14	45.56
	Lockdown level 2	2.85	2.64	.279	-2.32	8.03
	Lockdown level 3	1.07	1.53	.486	-1.93	4.07
	Lockdown level 4	-1.44	1.34	.284	-4.07	1.19
	Lockdown level 5	.92	.76	.227	-.57	2.41
	Rain	.01	.01	.208	.00	.02
	Daylight and Temperature	.20	.18	.268	-.16	.56
	Depression (HADS-D)	**.40**	**.10**	**< .001**	**.20**	**.60**
	Anxiety (HADS-A)	.06	.12	.618	-.17	.28
	Pain catastrophising (PCS)	**.60**	**.04**	**< .001**	**.51**	**.69**
	Exercise	**.08**	**.02**	**< .001**	**.05**	**.11**

NOTE. Significant effects highlighted in bold font.

exercise were associated with greater pain interference and tiredness.

Discussion

We studied the effects of UK government-imposed lockdown restrictions on pain intensity, pain interference, and tiredness in people with chronic pain across 11 months of the Covid-19 pandemic. Findings partly supported our hypotheses that more restrictive lockdown conditions would have a detrimental effect on pain-related outcomes, and that effects would partially be mediated by psychological distress. Specifically, full national lockdown (vs few/eased restrictions) did predict higher pain intensity, mediated in part by depression symptoms. However, we did not find a mediating role of pain catastrophising, nor did we find

Table 4. Theoretical Likelihood Ratio Tests to Ascertain Whether Model Fit was Significantly Improved at Each Step, Presented Separately for Each Outcome

	Model	df	AIC	BIC	Log likelihood	LR statistic	delta df	p
Pain intensity	1	7	23,278	23,320	-11,632			
	2	14	22,876	22,959	-11,424	415.83	7	< .001
	3	32	22,473	22,662	-11,205	439.13	18	< .001
	4	40	22,327	22,563	-11,123	162.37	8	< .001
Pain interference	1	7	10,599	10,640	-5292.3			
	2	9	10,465	10,519	-5223.7	137.29	2	< .001
	3	40	9540.7	9776.9	-4730.3	986.67	31	< .001
Tiredness	1	7	23,618	23,659	-11,802			
	2	9	23,256	23,309	-11,619	365.45	2	< .001
	3	40	22,646	22,882	-11,283	672.52	31	< .001

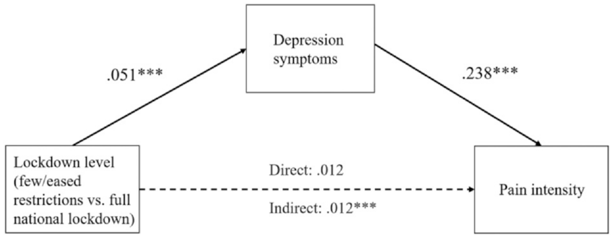

Figure 2. Mediation analysis showing that depression symptoms partially mediated effects of lockdown level on pain intensity. Standardised coefficients are shown (*** = $p < .001$); the dotted line indicates a non-significant direct path from lockdown level to pain intensity.

significant effects of lockdown on pain interference and tiredness. The latter outcomes were instead directly predicted by greater levels of depression, anxiety, pain catastrophising, and reduced exercise.

Lockdown restrictions can be expected to adversely affect psychological wellbeing and pain-related outcomes in people living with chronic pain. Prior to the current work, cross-sectional studies had found that people with chronic pain reported higher levels of anxiety and low mood compared to pain-free individuals at the start of the pandemic[12]; see also ref.[31] Several longitudinal studies used short time frames to measure the prospective impact of pandemic-related lockdown restrictions on psychological distress and pain outcomes. Three studies found *no* or *few* short-term effects (each covering a period of 2–3 months and all falling within the period of late Spring-Summer of 2020) of the pandemic on pain and psychological distress,[32–34] contradicting some cross-sectional studies (e.g.,[12,31,35]). Furthermore, two studies reported *improvements* in depressive symptoms, pain interference, and pain severity[36] from pre-pandemic scores to scores obtained two weeks[37] and one month[36] after lockdown regulations came into effect. However, at these points, restrictions had only been in place a short amount of time, and it was difficult to ascertain the trajectory of the pandemic and duration for which restrictions would be imposed. Furthermore, the Office for National Statistics found that, in general, people rested more and spent more time on leisure activities in March/April 2020, but this had reverted to pre-pandemic levels by September/October 2020,[38] that is, beyond the time window captured by the early studies. The present findings indicate that, as the pandemic continued, more stringent lockdown conditions did have a negative impact for chronic pain symptoms and that levels of depression symptoms played an important role in this effect.

In our longitudinal study, we focused on the impact of lockdown restrictions on pain-related outcomes, but also examined their impact on depression symptoms, and the link between psychological distress and pain outcomes. As noted above, full national lockdown predicted pain intensity but not interference or tiredness. Additionally,

Table 5. **Model Results for the Pain Interference and Tiredness Outcomes**

Model	Name	Pain interference Estimate	SE	p	95% CI lower	95% CI upper	Tiredness Estimate	SE	p	95% CI lower	95% CI upper
1	Intercept	6.12	.12	< .001	5.88	6.36	75.97	1.06	< .001	73.89	78.06
	Lockdown level 2	.13	.26	.608	-.38	.65	.71	2.84	.804	-4.86	6.28
	Lockdown level 3	.09	.13	.508	-.18	.36	2.6	1.49	.081	-.32	5.52
	Lockdown level 4	.14	.13	.283	-.12	.4	0	1.42	.999	-2.79	2.79
	Lockdown level 5	.1	.07	.175	-.04	.24	.26	.78	.736	-1.26	1.79
2	Intercept	6.11	.14	< .001	5.83	6.38	78.81	1.28	< .001	71.29	76.31
	Lockdown level 2	.04	.27	.895	-.49	.56	-.57	2.9	.845	-6.25	5.11
	Lockdown level 3	-.03	.16	.832	-.34	.27	2.09	1.68	.22	-1.21	5.38
	Lockdown level 4	.07	.14	.602	-.2	.35	-.18	1.49	.903	-3.1	2.74
	Lockdown level 5	.09	.08	.26	-.07	.24	1.16	.84	.169	-.49	2.82
	Rain	.00	0	.395	.00	.00	**.02**	**.01**	**.001**	**.01**	**.03**
	Daylight and Temperature	-.02	.02	.167	-.06	.01	.13	.18	.491	-.23	.48
3	Intercept	2.84	.18	< .001	2.48	3.19	53.11	1.97	< .001	49.24	56.98
	Lockdown level 2	.02	.23	.932	-.44	.48	-.16	2.75	.955	-5.55	5.23
	Lockdown level 3	-.14	.13	.287	-.41	.12	1.93	1.58	.222	-1.17	5.02
	Lockdown level 4	-.05	.12	.662	-.29	.18	-.38	1.37	.781	-3.08	2.31
	Lockdown level 5	-.09	.07	.212	-.22	.05	.18	.78	.816	-1.34	1.7
	Rain	.00	0	.071	.00	.00	**.03**	**.01**	**< .001**	**.01**	**.04**
	Daylight and Temperature	.00	.01	.823	-.03	.03	.39	.19	.043	.01	.76
	Depression (HADS-D)	**.09**	**.01**	**< .001**	**.07**	**.11**	**.81**	**.11**	**< .001**	**.6**	**1.03**
	Anxiety (HADS-A)	**.02**	**.01**	**.054**	**0**	**.04**	**.35**	**.12**	**.004**	**.11**	**.6**
	Pain catastrophising (PCS)	**.08**	**0**	**< .001**	**.07**	**.09**	**.33**	**.05**	**< .001**	**.24**	**.43**
	Exercise	**.01**	**0**	**< .001**	**.01**	**.01**	**.06**	**.01**	**< .001**	**.03**	**.09**

through the mediation model, we were able to determine that full national lockdown significantly predicted depression symptoms, and that depression symptoms partially accounted for the effects of lockdown on pain intensity. Focusing on psychological distress as predictors of pain and tiredness, higher levels of depression, anxiety, and pain catastrophising all predicted greater pain interference and tiredness. Whilst there is evidence for an adverse impact of full national lockdown on pain intensity, the model indicates that the effect was small, and it may thus be more fruitful to focus on the psychological impact of such restrictions, and target mood and pain catastrophising to reduce pain and tiredness in people with chronic pain. Depression and pain are closely linked,[39] though the direction of effect remains incompletely understood, and parallels have been proposed in terms of neural pathways involved in the chronification of both negative mood and pain,[40] suggesting joint underlying mechanisms. Though it is important to note that more severe lockdown restrictions predicted lower mood in people with chronic pain, addressing such low mood seems to be the area of priority.

An interesting finding of the present study was that pain intensity—but not pain interference or tiredness—was impacted by the level of lockdown. A recent study from Spain showed that the relationship between pain interference and pain intensity during lockdown was modulated by psychological factors including past trauma.[41] Research from the United States indicates that implementation of new coping strategies during lockdown reduced levels of pain interference, and the authors also demonstrated roughly similar proportions of patients showing improvement in pain interference, compared to those who showed no change or detriment during lockdown.[31] Similarly, another study compared the beginning of social distancing to a one-year follow up and identified three distinct subgroups of chronic pain patients that differed in pain interference outcomes. Specifically, a subgroup of patients with higher psychosocial predominance of pain at the onset of social distancing demonstrated greater pain interference and loneliness, and lower levels of mindfulness and optimism at follow up.[42] Our results also demonstrate great variability in pain interference between patients. It is possible that during lockdown restrictions, pain interference may have been modulated by other relevant psychological factors including past trauma, resilience, and optimism. Similarly, tiredness levels could be modulated by enforced inactivity or mitigated by new coping strategies. Therefore, we believe that the impact of patient factors on complex outcomes such as pain interference and tiredness during lockdown offers an important topic for further study, with the potential to inform clinical strategies that could be stratified by particular patient phenotypes.[42]

There have been five pandemics since the 1918 Spanish flu, and currently, there are several known pathogens capable of causing the next pandemic.[43] The impact of the Covid-19 outbreak serves to highlight the need to focus on future threats and to raise preparedness.[44] Improved understanding of how psychological or lockdown-related factors can influence pain and other symptoms (e.g., tiredness) during pandemic-imposed restrictions can help inform clinical strategies and pain-management approaches in response to future public health challenges. This may be especially pertinent as more and more people develop chronic pain, with contracting Covid-19 linked to higher incidence of chronic pain.[18,45,46]

Moreover, the findings from the present study may also have broader relevance for alternative scenarios that can elicit elevated levels of stress, social isolation, or reduced access to healthcare. Pertinent examples include increased severity of chronic pain symptoms in situations including war, civil unrest, or the aftermath of terrorist attacks.[47,48] Online technology can be utilised to improve levels of social support, combat social isolation, and to offer treatment provision,[49] but it is important to consider variability in access to digital technologies amongst vulnerable groups, particularly the elderly.[50] Overall, an improved understanding of the myriad of complex patient and social factors impacted during the Covid-19 pandemic lockdowns can be used to adapt clinical strategies to mitigate associated suffering in chronic pain patients in future.[2]

A strength of the study was that we collected data across 13 time points. As we did not know in advance when lockdown restrictions would end or re-start, we wanted to ensure we captured people's experiences across fluctuating lockdown restrictions. We measured a range of psychological and external factors. As we began data collection in April 2020, none of the measures chosen could have been validated within the context of the Covid-19 pandemic. To reduce participant burden, we used both single items and measures validated under more stressful conditions (e.g., the HADS was validated in hospital inpatients) to capture our variables of interest. Of note, participants completed all measures repeatedly across changing lockdown conditions, giving an indication of how variables changed over time.

As a limitation, we did not collect data regarding race, ethnicity, socioeconomic status, level of education, or employment status, which could have offered additional insights. There is intersectionality between chronic pain and factors such as ethnicity and socioeconomic status. In the UK, being from an ethnic minority background and living in areas of deprivation can exacerbate the likelihood and impact of chronic pain, including reduced help-seeking and access to healthcare.[51] Moreover, the association between depression and chronic pain may differ by ethnicity,[52] and people from ethnic minority backgrounds and those with lower socioeconomic status also had more negative outcomes (including higher rates of death) due to the Covid-19 coronavirus during the pandemic.[15] Regrettably, we were not able to stratify our analyses by ethnicity or socioeconomic status, but it is important to carefully consider intersectionality in future research.

Furthermore, we did not ask participants whether they had contracted Covid-19 at any of the time points, chiefly because tests for Covid-19 were not available at the outset of the study. Nevertheless, at later time points, we could have asked participants about any Covid-19 infection, as this might have impacted symptoms, such as pain and fatigue.[53] While Covid-19 infections could have impacted our data, fluctuations in pain-related outcomes did not show the same pattern as the infection incidence data from 2020 to 2021, dominated by two successive waves (see Fig 1). Furthermore, we did not ask participants about their Covid-19 vaccination status, again as vaccinations only became available in the UK from December 2020. While short-lived pain sensations (local and generalised) were described as common adverse effects of the vaccine, symptoms had generally disappeared by the fourth day.[54] In addition, most people who had been vaccinated by the end of our data collection period (March 2021) were over 70 years old. At time point 10 (32 weeks into the study, ca. December 2020), only $n = 9$ participants were aged 70 or over (rising to $n = 11$ at the final time point 13), and therefore the number of people likely to have been vaccinated and any resulting effects are likely to have been negligible. In addition, some participants were recruited through a pain clinic, but this subsample was too small to make meaningful comparisons with our participants recruited from the community. Although implications for research and clinical practice may differ for these two groups, participants recruited from the community might also have accessed specialist pain management services, even if we did not recruit them from such a service, and so we would not have been able to draw firm conclusions from such a comparison.

We also obtained information on self-isolation (complete shielding, which was advised for different vulnerable groups) only at baseline, and participants' isolation status may have changed across the course of the study. Reflecting on an additive effect between social restrictions and isolation, Amja and colleagues[20] found that social isolation was 'accentuated' by social distancing rules and that digital forms of communication could replace in-person contact only for individuals with existing social connections. Further, greater satisfaction with participation in social roles and activities was found to be linked to reduced pain in people with chronic pain during the first national lockdown.[55] Obtaining information on self-isolation and satisfaction with participation in social activities at each time point would have been interesting to consider from this perspective. We also did not directly ask participants whether or not they personally had adhered to government-imposed lockdown restrictions. Lastly, while we asked participants about the type of chronic pain (see ref.[12]), responses were provided in free text format, meaning we had to attempt to match these open-ended replies to the ICD-11 categories. We therefore felt this data was not reliable enough to warrant grouping participants by type of chronic pain and presented the groups for descriptive purposes only.

Conclusions

In conclusion, over a period of 11 months, more stringent lockdown restrictions, specifically a full national lockdown, were associated with greater pain intensity, due partly to adverse effects on mood. Pain interference and tiredness were predicted by depression, anxiety, pain catastrophising, and also reduced exercise. While we focused on chronic pain, some of these insights may be important for other clinical groups, such as people living with diabetes, as there is some indication from research carried out early in the pandemic that Covid-19 increased psychological distress in this population,[56] but longer-term effects are still unclear. In sum, identifying predictors of pain and tiredness can give an indication of which psychological factors to measure and track in future public health crises—and beyond—to help tailor support for people living with chronic pain and potentially other long-term conditions characterised by pain and tiredness.

Ethical Permissions

Local Research Ethics Committee, University of Liverpool.

Disclosure

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The authors declare they have no conflicts of interest.

Data Availability

Data is available from the authors on request.

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