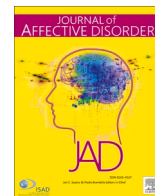




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# Association between workplace and mental health and its mechanisms during COVID-19 pandemic: A cross-sectional, population-based, multi-country study

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## ABSTRACT

**Background:** The COVID-19 pandemic worsens populations' mental health. However, little is known about the COVID-19-related mental health among remote workers.

**Methods:** We retrieved data from survey of Health, Ageing and Retirement in Europe, covering 27 countries. Eligible people were those employed. The main outcome is the mental disorder, covering four aspects: depression, anxiety, sleep disorder, and loneliness. Country-specific weighted mixed models were fitted to estimate the association of workplaces with mental health, controlled for age, gender, education level, living alone, making ends meets, working hours, closing to suspected or confirmed COVID-19 cases, received anti-virus protection, social contact, disability, and chronic disease. Moderate analyses were conducted to explore possible mechanisms.

**Results:** 11,197 participants were included, among them 29.3% suffered at least one worse mental disorder. After controlling for covariates, compared with those who worked at the usual workplace, those who worked at home only or part of the time did not associate with worse mental disorders ( $p$ -value  $\geq 0.1395$ ), and those who worked at neither the usual workplace nor home had a 55% higher likelihood of suffering from worse mental disorders (OR = 1.55, 95%CI 1.03–2.36). The mediation analyses identified three indirect pathways by which workplaces influence mental health, including making ends meets, social contact, and receiving anti-virus protection. Detailed results on subtypes of mental disorders were also provided.

**Limitations:** All assessments were self-reported, resulting in a risk of method bias.

**Conclusions:** During the COVID-19 pandemic, working at other places, neither at the usual workplace nor home, worsened mental health. Evidence provided in this study will contribute to more nuanced and practical public health policy strategy making.

## 1. Introduction

The spread of the SARS-CoV-2 has brought about unexpected changes to people's lives in many ways, one of which is driving people worldwide to work from home (Vyas and Butakhieo, 2021). Working from home (WFH), also known as remote work, telework, or mobile work, is expected to reduce the risk of COVID-19 infection and has been widely implemented as part of the social distancing policies (Kawashima et al., 2021).

Piles of evidence have shown that increased mental problems, such as depression, anxiety, distress, and insomnia, are related to both the COVID-19 pandemic and social distancing policies. However, few studies have focused on those WFH, and the majority of available evidence comes from pre-COVID-19 with inconsistent results. Two surveys from the US (Xiao et al., 2021a, 2021b) and Japan (Shimura et al., 2021) reported decreased mental well-being among those WFH during the COVID-19 pandemic. On the contrary, the surveys conducted in China (Zhang et al., 2020), Bangladesh (Ara et al., 2020), and another two

**Abbreviations:** ADL, Activities of daily living; CI, Confidence interval; GLMM, Generalised linear mixed model; OR, Odds ratio; SHARE, Survey of Health, Ageing and Retirement in Europe; WFH, Working from home.

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surveys conducted in the US (Abrams et al., 2021; McDowell et al., 2021) reported an insignificant association between remote working and worse mental health during the COVID-19 pandemic. A rapid review of 23 studies, most of which were conducted before the COVID-19 pandemic, obtained similar inconclusive results, namely WFH could have negative or positive impacts on mental health (Oakman et al., 2020).

Some studies explored the possible mechanisms by which the COVID-19 pandemic influenced mental burden (Orsolini et al., 2020), although corresponding evidence is not specifically for those WFH. In general, the anti-virus measures as well as the fear of COVID-19 restricted people's normal lives and behaviors, both of which directly or indirectly worsened their mental health (Gostin and Wiley, 2020; Kramer and Kramer, 2020). Some studies or reviews also explored possible mechanisms for the effects of external events on the mental issues (like suicidal behavior) from a pathophysiological perspective, and highlighted the role of neurobiological biomarkers, neuro-immunological biomarkers, and brain-derived neurotrophic factors (De Berardis et al., 2018; Orsolini et al., 2020). More relevantly, several reviews summarised the potential predictor factors for mental well-being among workers, and stated that the inconsistency of current evidence may depend on various moderators such as: worrying about involuntary unemployment, wage reduction, alterations of working conditions and environments, risk of contagion of COVID-19, adoption of preventive procedures, and social exclusion or stigma (Giorgi et al., 2020; Oakman et al., 2020; Preti et al., 2020; Vindegaard and Benros, 2020; Xiong et al., 2020). These evidence could provide the theoretical foundation for studies of the association between WFH and mental health during the COVID-19 pandemic.

There is little focus on those WFH and inconsistent results impede the customisation of intervention for this population group. More than 3.4 billion people in 84 countries have been confined to their homes, as estimated in the early period of the COVID-19 pandemic (Bouziri et al., 2020). This number could be larger beyond the early period of the COVID-19 pandemic and the change in work style caused by the pandemic may continue after the pandemic. It was estimated that approximately 40% of employees in companies will utilize a remote working model in the future, and that 37% of companies expect more than 25% of their employees will work in hybrid models that combine remote and onsite work (Kaufman et al., 2020). In addition, the COVID-19 pandemic has created a great chance for considering both work and life. A detailed understanding of the factors in this new environment that relate to mental well-being is instrumental to ensuring positive impacts for office workers who might WFH in near future (Xiao et al., 2021a, 2021b). All of these highlight the corresponding evidence on remote workers has a broad and long-lasting audience and practical contributions.

In this study, we aimed to explore the association between workplaces and mental health as well as its possible mechanisms during the COVID-19 pandemic, with a special focus on remote workers, using a cross-sectional population-based survey from 27 countries. We hypothesised that remote workers might or might not suffer worse mental health compared to those who worked at the usual workplace, but this possible association was mediated by factors related to income, working hours, social contact, and subjective sense of security related to COVID-19.

## 2. Methods

### 2.1. Study design and participants

We used publicly available data from the SHARE project (Survey of Health, Ageing and Retirement in Europe). SHARE is a biennial nationally representative individual survey on people aged  $\geq 50$  covering 27 countries. Importantly, it ran during the 2020 COVID-19 pandemic. Each participant completed a standardised questionnaire via internet/

telephone assessments, described elsewhere (Annette et al., 2020; Börsch-Supan, 2020). Data included socioeconomic status, health, mental health, infections and healthcare, changes in work and economic situation, and social and family networks. We primarily used data from the survey in 2020. In this study, we only included people who were still employed at the time COVID-19 broke out, and excluded those who were retired, laid off, or unemployed.

The SHARE study is guided by international research ethics principles, such as the Respect Code of Practice for Socio-Economic Research and the 'Declaration of Helsinki'. SHARE was reviewed and approved by the Ethics Council of the Max Planck Society.

### 2.2. Key measures

**Mental health.** The SHARE collected the influence of the COVID-19 pandemic on an individual's mental health covering four aspects: depression, anxiety, sleep disorder, and loneliness. The items used were: for depression, "in the last month, have you been sad or depressed" with response yes or no; for anxiety, "in the last month, have you been felt nervous, anxious, or on edge" with response yes or no; for sleep disorder, "in the last month, have you had trouble sleeping recently" with response "trouble with sleep or recent change in pattern" or "No trouble sleeping"; and for loneliness, "in the last month, how much of the time do you feel lonely? Often, some of the time, or hardly ever or never?". For those with answer "yes", "trouble with sleep or recent change in pattern", "Often", or "some of the time", the severity of their mental problem for each aspect was separately evaluated by another item, "has that been more so, less so, or about the same as before the outbreak of Corona?". In this study, participants with the answer "more so" were coded as depressed than before, nervous or anxious than before, sleeping difficulty than before, or lonely than before. Participants who suffered at least one of the above four problems were judged as suffering worse mental health overall.

**Workplace** was collected with one item "Since the outbreak of Corona, some people worked at home, some at their usual workplace outside their home, some both. How would you describe your situation?" with answer worked at home only, worked at the usual workplace, worked from home and at the usual workplace, and none of these.

### 2.3. Covariates

We examined the following socio-demographic variables: age (years), gender (male vs female), education level, and living alone (yes vs no). The education level was matched from previous waves, and was divided into four categories based on the International Standard Classification of Education: primary education or lower, lower secondary education, upper secondary education, and post-secondary education or above. We also examined the following variables that were plausible risk or protective factors for worse mental health during the COVID-19 pandemic.

**Making end meets** was collected with one item "thinking of your household's total monthly income since the outbreak of Corona, would you say that your household is able to make ends meet with great difficulty, with some difficulty, fairly easily, or easily?", with answering latter two choices coded as yes in this study.

**The working hour** was collected with one item "Did you increase your working hours since the outbreak of Corona?" with the answer yes or no.

**Disability** was assessed by six basic activities of daily living (ADLs) (dressing, walking across a room, bathing, eating, getting in and out of bed, toileting) and nine instrumental ADLs (using maps, preparing a hot meal, shopping for groceries, making phone calls, taking medications, doing work around the house or garden, managing money, leaving the house, and doing personal laundry) (Chen et al., 2022; Steptoe and Di Gessa, 2021). ADL was assessed by item "if you have any difficulty with these activities because of a physical, mental, emotional or memory

problem. Exclude any difficulties you expect to last less than three months”. The data was matched from the last wave, and participants who responded positively to one or more items were defined as having ADL disability (Step toe and Di Gessa, 2021).

**Chronic disease** was judged from self-assessed conditions by an item “Do you have any of the following illnesses or health conditions?” with options hip fracture, diabetes, hypertension, heart attack, chronic lung disease, cancer, and other self-mentioned illnesses or health conditions.

**Social contact.** The first question asked, “Since the outbreak of Corona, how often did you have personal contact, that is, face to face, with the following people from outside your home?”, with five responses: daily, several times a week, about once a week, less often, and never. The question was asked separately in relation to own children, own parents, other relatives, and other non-relatives like neighbours, friends, or colleagues. A parallel set of the question was asked regarding the frequency of “contact by phone, email or any other electronic means” with these same relationship categories. For this study, we categorized participants with the response of less often or never for at least one of the above questions as contact less often or never.

**Close to suspected or confirmed COVID-19 cases** was judged based on four items “Since the outbreak of Corona, did you or anyone close to you experience symptoms that you would attribute to the Covid illness, e.g. cough, fever, or difficulty breathing?”, “Have you or anyone close to you been tested for the Coronavirus and the result was positive, meaning that the person had the Covid disease?”, “Have you or anyone close to you been hospitalized due to an infection from the Coronavirus?”, and “Has anyone close to you died due to an infection from the Coronavirus?”, with a response yes or no. Participants who responded “yes” to at least one of the above questions were categorized as close to suspected or confirmed COVID-19 cases.

**Received any anti-virus protection** was judged with one item “Did you get any protection such as masks, gloves, protective screens, disinfection fluid?” with response yes or no.

#### 2.4. Statistical analysis

Survey weighting was used to account for sampling design (including the unequal probability of selection, clustering, and stratification). To describe the basic characterises, categorical variables were reported as number and weighted percentage (95% confidence interval), and continuous variables were reported as weighted mean (95% confidence interval).

To estimate the association between workplace and mental disorders, we adopted weighted generalised linear mixed models (GLMM), with mental disorder as the dependent variable and workplace as the predictor, controlling for other covariates. Intercept and workplace were treated as random variables at the country level.

To explore the possible mechanisms by which the workplace influence the mental disorder, we further conducted six weighted multi-level mediation analyses to test whether the workplace worse people’s mental health during the COVID-19 pandemic via the following pathways: a, influencing their likelihood of making ends meets; b, influencing their working hours; c, influencing their frequency of social contact; d, influencing their likelihood of living alone; e, influencing their sensitivity to suspected or confirmed COVID-19 cases close to them; and f, influencing their likelihood of receiving anti-virus protection. As indicated by our results, it was working at other places, neither at the usual workplace nor home, that worsened the mental health during the COVID-19 pandemic. In the mediation analysis, for ease of understanding and interpretation of the results, workplace was only divided into a binary variable (working at usual workplaces, home, or both, vs neither), with former as reference.

Analyses were performed using R (v3.6.0). Statistical significance was defined as  $P < 0.05$ . All tests were two-tailed.

### 3. Results

After excluding 41,113 respondents who were retired, laid off, or unemployed, a total of 11,197 respondents from the SHARE were included in this study. Table 1 summarises their basic characteristics. The average age was 59.4 years old. Among these respondents, 47% were female, more than 75% received upper secondary or above education, 18.7% lived alone, 68.4% made end meets at least, 7.2% had at least one ADL difficulty, and 51.7% suffered at least one chronic disease. 52.1% of respondents worked at the usual workplace, 14.3% worked at home only, and 18.2% worked at other places. 24.4% of the respondents believed that they are close to suspected or confirmed covid-19 cases, and more than half of respondents (57.2%) received anti-virus protection. Only a few respondents (0.2%) contact less often than before. As for mental health, 29.3% suffered at least one worse mental problems, specifically 21.1% of respondents felt more nervous or anxious than before, 14.8% of respondents became more depressed than before, 14.8% of respondents had more sleeping difficulty than before, and 7% of respondents felt lonelier than before.

Table 2 presents the regression results on mental disorders. Compared with those who worked at the usual workplace, those who worked at home only and those who shifted between the usual workplace and home did not associate with worse mental disorders as well as their subtypes ( $p\text{-value} \geq 0.1395$ ). In contrast, those who worked at other places (neither usual workplace nor home) had a 55% higher likelihood of suffering from worse mental problems (OR = 1.55, 95%CI 1.03–2.36), including an 80% higher likelihood of experiencing depression (OR = 1.80, 95%CI 1.07–3.03), a 60% higher likelihood of experiencing sleep difficulty (OR = 1.60, 95%CI 1.15–2.23), and a 73% higher likelihood of experiencing nervous or anxiety (OR = 1.73, 95%CI 1.13–2.69), but working at other places had no association with a worse feeling of loneliness (OR = 0.99, 95%CI 0.51–1.92).

Table 3 presents the proportion of the effect of the workplace on

**Table 1**  
Basic description.<sup>a</sup>

Variable	N (=11,197)	Weighted mean or proportion (95% confidence interval)
Age (year) <sup>a</sup>	NP	59.4(59.3, 59.6)
Gender (=Female)	6109	47(44.7, 49.4)
Education level		
Primary education or lower	835	8.7(7.2, 10.4)
Lower secondary education	1192	14.4(12.6, 16.5)
Upper secondary education	4575	42.2(39.9, 44.5)
Post-secondary education or above	4595	34.7(32.5, 36.9)
Live alone (= true)	1732	18.7(16.9, 20.5)
Make end meets at least (= true)	7664	68.4(66.2, 70.5)
Working hour increased (= true)	1165	11.9(10.4, 13.6)
Any suspected or confirmed covid-19 cases close to you (= true)	2259	24.4(22.4, 26.5)
Received any anti-virus protection (= true)	6266	57.2(54.9, 59.5)
Contact less often or never (= true)	30	0.2(0.1, 0.5)
Any adl difficult (= true)	893	7.2(6.1, 8.6)
Any chronic disease (= true)	6072	51.7(49.3, 54)
Workplace		
Worked at the usual workplace	5809	52.1(49.8, 54.5)
Worked at home only	1848	14.3(12.8, 15.9)
Both	1572	15.4(13.7, 17.2)
Neither	1880	18.2(16.6, 20)
Any mental disorders	3207	29.3(27.2, 31.6)
Depressed than before (= true)	1482	14.8(13.2, 16.5)
Sleeping difficulty than before (= true)	837	9.1(7.8, 10.5)
Lonely than before (= true)	806	7(6, 8.1)
Nervous or anxious than before (= true)	2306	21.1(19.1, 23.2)

NP, not applicable.

<sup>a</sup> Data for age present as weighted mean (95%CI). NP, not applicable.

**Table 2**  
Weighted logistic regression on mental disorders.

Interested variable	Any mental health (=true)		Depressed than before (=true)		Sleeping difficulty than before (=true)		Lonely than before (=true)		Nervous or anxious than before (=true)	
	OR(95%CI)	P value	OR(95%CI)	P value	OR(95%CI)	P value	OR(95%CI)	P value	OR(95%CI)	P value
<b>Workplace</b>										
Worked at the usual workplace	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Worked at home only	1.12(0.72, 1.73)	0.6197	1.12(0.64, 1.93)	0.6966	0.62(0.30, 1.28)	0.1974	0.73(0.36, 1.49)	0.3893	1.40(0.87, 2.27)	0.1656
Both	1.27(0.92, 1.73)	0.1395	1.02(0.68, 1.52)	0.9144	1.14(0.68, 1.92)	0.6237	1.25(0.73, 2.10)	0.4155	1.23(0.86, 1.79)	0.2568
Neither	<b>1.55(1.03, 2.36)</b>	<b>0.0372</b>	<b>1.80(1.07, 3.03)</b>	<b>0.0269</b>	<b>1.60(1.15, 2.23)</b>	<b>0.0054</b>	0.99(0.51, 1.92)	0.978	<b>1.73(1.13, 2.69)</b>	<b>0.0133</b>
<b>Covariates</b>										
Age (year)	0.99(0.97, 1.01)	0.2375	0.99(0.96, 1.01)	0.2006	0.96(0.94, 0.99)	0.0067	0.99(0.96, 1.02)	0.5568	0.99(0.97, 1.01)	0.2346
Gender (= Male)	<b>0.42(0.34, 0.53)</b>	<b>&lt;0.0001</b>	<b>0.40(0.29, 0.54)</b>	<b>&lt;0.0001</b>	<b>0.53(0.38, 0.73)</b>	<b>0.0001</b>	<b>0.53(0.38, 0.76)</b>	<b>0.0005</b>	<b>0.46(0.36, 0.60)</b>	<b>&lt;0.0001</b>
<b>Education level</b>										
Primary education or lower	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Lower secondary education	1.13(0.70, 1.82)	0.6179	1.23(0.68, 2.23)	0.4966	0.81(0.40, 1.65)	0.5664	0.94(0.45, 1.95)	0.8727	1.26(0.75, 2.12)	0.3879
Upper secondary education	0.91(0.64, 1.31)	0.6147	0.88(0.58, 1.35)	0.5609	1.12(0.61, 2.08)	0.7203	0.93(0.50, 1.75)	0.8364	0.90(0.61, 1.32)	0.5796
Post-secondary education or above	0.99(0.68, 1.43)	0.9575	0.83(0.53, 1.28)	0.4027	1.52(0.82, 2.83)	0.1848	1.11(0.56, 2.16)	0.7802	0.99(0.68, 1.46)	0.9782
Live alone (= true)	1.38(1.07, 1.77)	0.0112	1.30(0.95, 1.75)	0.0962	1.38(0.93, 2.03)	0.1044	<b>2.44(1.72, 3.46)</b>	<b>&lt;0.0001</b>	1.15(0.87, 1.54)	0.3235
Contact less often or never (= true)	<b>2.92(1.12, 7.61)</b>	<b>0.0283</b>	<b>6.30(2.18, 18.17)</b>	<b>0.0006</b>	<b>4.35(1.06, 17.81)</b>	<b>0.0413</b>	<b>9.78(3.78, 25.53)</b>	<b>&lt;0.0001</b>	<b>4.48(1.62, 12.55)</b>	<b>0.0041</b>
Make end meets at least (= true)	<b>0.78(0.61, 0.98)</b>	<b>0.0355</b>	<b>0.75(0.57, 0.98)</b>	<b>0.0371</b>	<b>0.68(0.50, 0.94)</b>	<b>0.0187</b>	<b>0.66(0.47, 0.93)</b>	<b>0.0176</b>	<b>0.69(0.53, 0.90)</b>	<b>0.0064</b>
Working hour increased (= true)	1.11(0.73, 1.67)	0.6315	1.21(0.67, 2.20)	0.5269	1.07(0.66, 1.75)	0.7918	0.78(0.43, 1.42)	0.4165	1.23(0.78, 1.97)	0.3644
Any adl difficult (= true)	1.16(0.80, 1.70)	0.4194	1.45(0.95, 2.20)	0.0873	<b>1.86(1.15, 3.03)</b>	<b>0.0119</b>	1.00(0.61, 1.63)	0.9922	0.98(0.67, 1.43)	0.9035
Any chronic disease (= true)	<b>1.39(1.12, 1.73)</b>	<b>0.0031</b>	<b>1.42(1.07, 1.88)</b>	<b>0.0147</b>	<b>1.62(1.16, 2.25)</b>	<b>0.0041</b>	0.98(0.70, 1.35)	0.8862	<b>1.35(1.04, 1.73)</b>	<b>0.0219</b>
Any suspected or confirmed covid-19 cases close to you (= true)	<b>1.52(1.20, 1.92)</b>	<b>0.0005</b>	1.31(0.98, 1.75)	0.0638	<b>1.63(1.19, 2.27)</b>	<b>0.0029</b>	1.22(0.88, 1.72)	0.2404	<b>1.46(1.13, 1.92)</b>	<b>0.0041</b>
Received any anti-virus protection (= true)	0.84(0.58, 1.23)	0.3885	0.90(0.56, 1.48)	0.6888	0.60(0.33, 1.09)	0.0964	<b>0.48(0.25, 0.89)</b>	<b>0.0193</b>	1.06(0.71, 1.58)	0.7716

mental disorders explained by the indirect effect via the possible intervenable variables in Table 1. Compared with working at the usual workplace or home, working at other places did not influence mental disorders and their subtypes by increasing people's working hours (p-value  $\geq 0.352$ ), or by increasing people's likelihood of living alone (p-value  $\geq 0.264$ ), or by making people more sensitive to whether they are close to suspected or confirmed COVID-19 cases (p-value  $\geq 0.434$ ), but did influence the mental problems and their subtypes by decreasing people's likelihood of making ends meets (p-value  $\leq 0.044$ ), by increasing people's likelihood of contacting less (p-value  $\leq 0.048$ ), or by decreasing people's likelihood of receiving anti-virus protection (p-value = 0.014). The indirect pathway via making end meets or contacting less explained 9.2–17% or 6.1–9.8%, respectively, of the total effect of workplace on mental disorders and subtypes, while the indirect pathway via receiving anti-virus protection explained 70.7% of the total effect of workplace on feeling alone.

#### 4. Discussion

##### 4.1. Statement of principal findings

Using a reprehensive dataset, we found that compared with those who only worked at the usual workplace, WFH full or part of the time

did not worsen their mental health, while people working at other places (neither at the usual workplace nor home) had a 55% higher likelihood of experiencing worse mental health. We also found that besides the direct effect, working at other places had indirect associations with worse mental health via changing people's ability to make ends meets, frequency of social contacting, and chance of receiving anti-virus protection, but not via changing people's working hours, likelihood of living alone, or by making people more sensitive to whether they are close to suspected or confirmed COVID-19 cases.

##### 4.2. Possible explanations and comparison with other studies

Our finding on those WFH full or part of the time keeps in line with studies conducted in China (Zhang et al., 2020), Bangladesh (Ara et al., 2020), Spain (Ruiz-Frutos et al., 2021), the UK (Andersson, 2021), and the US (Abrams et al., 2021; McDowell et al., 2021), all of which also concluded no association between remote working and worse mental health. Although few studies, like the ones conducted in India (P, 2021) and Poland (Izdebski and Mazur, 2021), reported different results, which were compared to those who worked in the traditional workplace, people who worked remotely more often signalled an intensification of the symptoms of mental health disorders. The inconsistency of results could be owing to differences in the characteristics of sampled

**Table 3**  
Proportion of effect explained by the indirect effect<sup>a</sup>.

Indirect effect via of	Any mental disorders (= TRUE)	Depressed than before (= TRUE)	Sleeping difficulty than before (= TRUE)	Lonely than before (= TRUE)	Nervous or anxious than before (= TRUE)
Make at least end meets(= TRUE)	11.4(0.4, 51.6), 0.0440	9.9(0.4, 37.8), 0.0360	9.2(1.2, 29.1), 0.0180	22.8 (-460.0, 370.9), 0.4040	17.0(2.7, 74.5), 0.0320
Working hour increased (= TRUE)	-5.7 (-58.6, 18.9), 0.5800	-7.6 (-60.5, 15.7), 0.4880	-1.1 (-20.9, 11.6), 0.8780	9.1 (-286.9, 346.1), 0.6740	-12.3 (-127.6, 72.4), 0.3520
Contact less often or never(= TRUE)	6.8(0.1, 39.8), 0.048	9.8(0.9, 43.8), 0.0100	6.1(0.0, 32.1), 0.0480	32.9 (-298.1, 334.4), 0.3460	10.0 (-0.1, 54.2), 0.0520
Live alone (= TRUE)	3.0(-3.0, 23.8), 0.2640	1.5(-1.8, 11.1), 0.3480	1.5(-1.6, 9.7), 0.3220	11.1 (-216.4, 215.0), 0.5660	1.0(-7.5, 11.4), 0.5580
Any suspected or confirmed COVID-19 cases close to you(= TRUE)	3.1(-9.7, 22.9), 0.4420	1.1(-4.1, 10.9), 0.4720	1.9(-4.3, 9.8), 0.4340	0.7 (-55.7, 35.2), 0.8000	2.9 (-14.3, 24.6), 0.4620
Received any anti-virus protection (= TRUE)	26.8 (-8.2, 82.4), 0.1240	17.1 (-19.4, 64.0), 0.3160	16.6 (-14.6, 56.8), 0.2600	70.7 (15.4, 368.6), 0.0140	19.2 (-32.9, 110.9), 0.3980

<sup>a</sup> Data present as proportion (95%CI) and p value, extracted from multilevel mediation analysis. As indicated the results in Table 2 that it is working at other places, neither at the usual workplace nor home, that worse the mental health during the COVID-19 pandemic. In the mediation analysis, to easy the understanding and interpretation of the results, the workplace was only divided into a binary variable (working at usual workplaces, home, or both, vs neither), with former as reference.

participants. The average age of participants in our study was 59.4 years old, it was higher than that (45 years) in the study conducted in Poland (Izdebski and Mazur, 2021). Studies stated that WFH during the COVID-19 pandemic could be more beneficial for older (senior) workers and their mental health, because WFH could provide them with more flexible schedules and increased freedom and work-life balance (Abrams et al., 2021; Koc-Menard, 2009; Loretto and Vickerstaff, 2015; Maestas et al., 2018), as well as lower their probability of getting exposed to SARA-COV-2, which has been a major concern in older populations (Brooke and Jackson, 2020). Studies supporting the association between WFH and worse mental health hold the opinion that remote workers usually felt the increased intensity of their work, the subjective-perceived increased intensity of work could worsen remote workers' mental health (DeFilippis et al., 2020; Tavares, 2017). However, this opinion was not supported by our results on working hours, which neither had a significant direct effect (Table 2) nor functioned as a significant indirect pathway for the workplace (Table 3).

An interesting finding of our study is that remote workers working at other places (neither at the usual workplace nor home) had a higher likelihood of suffering from worse mental health. Compared to the usual workplace or home, other workplaces means unfamiliarity for the workers. During the COVID-19 pandemic, this unfamiliarity may mean unknowns and uncertainty of the risk of COVID-19 or of timely treatment if were infected. In addition, this unfamiliarity can also mean possible stigma and exclusion. Particularly, the progressive stigma was one of the collateral phenomena spreading alarmingly at the early period of the COVID-19 pandemic (Bruns et al., 2020; Logie and Turan,

2020). This explanation can be indirectly confirmed by our finding in Table 3, which indicated that the percentage explained by the indirect effect of receiving anti-virus protection accounted for 70.7% of the total effect of the workplace on feeling alone. For remote workers working at other places, it was highly plausible to assume that receiving anti-virus protection could highly increase their sense of local belonging, weaken their sense of uncertainty, or decrease their fear of possible stigma or exclusion. Furthermore, during the COVID-19 pandemic, intensive workplace measures were proven to be beneficial for promoting and maintaining employees' mental health and work performance (Sasaki et al., 2020), but the corresponding measures may not be easily implemented at other places for remote workers. The above explanation could be supported by the theory of work adjustment to some extent. This theory highlights that changes on work environment could constrain individuals' adaptation to new environmental demands (Birimoglu Okuyan and Begen, 2022; Dawis, 2000; Nelson, 1990; Nicholson, 1984).

We further explored the possible mechanism by which workplaces influence mental disorders. The well documented associations of higher economic status (Abrams et al., 2021; Guo et al., 2020; Witteveen and Velthorst, 2020; Xiao et al., 2021a, 2021b) and frequent social activity (Atendorf and Gruber, 2021; Russo et al., 2021; Tavares, 2017) with better mental health were also confirmed in our study. For remote workers who worked neither at the usual place or home, they could pay more for drinks, meals and accommodation while may not get more income due to serious deterioration of the economy, and have less face-to-face communication with their colleagues, families, or friends (Shimazu et al., 2020). It was easy to understand that both are significant indirect pathways for workplace influencing mental disorders. Although the association of living alone and worse mental health was also documented (Chen et al., 2020; Cruyt et al., 2021; Guo et al., 2020; Li and Wang, 2020) and confirmed in our study, it was not a significant indirect pathway for the workplace. The possible explanation is that it was the social activity by which living alone worked on mental health, and social activity was specifically controlled or explored in our study.

#### 4.3. Strengths and limitations

To our knowledge, this is the first study to systemically assess the association between workplace and mental health using population-based and multi-national representative data. This study contributes to our understanding of how workplaces influence employees' mental health. The subgroup analysis (subtype of mental disorders and subtype of remote workers) and the mechanism exploration allowed for more nuanced and practical public health policy strategies to be made. Specifically, our findings recommend that under the COVID-19 pandemic, WFH is a mental health-friendly social distancing measures (especially for the senior workers), but a mental health-unfriendly one for those remote workers working at other places. For the later one, our findings also recommend that increasing their sense of local belonging by helping them connecting with local volunteer teams or medical assistance team may be an effective measure to maintain their mental health.

A key limitation of this study is the cross-sectional design. Although the items used to collect the individual's mental health were specified to compare with pre-outbreak of COVID-19, it still cannot ensure a causal inference. Secondly, it is plausible to expect the association between workplace and mental health is a cumulative relationship, but the data from the SHARE project only covered the early period of the COVID-19 pandemic. Thirdly, the data we used only included people aged 50 years old or above. As we discussed, our results may not generalise to younger employees. Fourthly, due to cultural reasons, the acceptance of remote working in European countries has always been relatively high, so the supporting measures for remote working during the COVID-19 pandemic are relatively complete. This further limits the generalisation of our research to countries or regions where remote working is not well-accepted, especially for the finding of insignificant association between WFH and worse mental health identified in our study. Fifthly,

when evaluating the relationship between workplaces and employee mental health, it is also necessary to be aware of whether the employee experienced remote working before the COVID-19 pandemic (Niu et al., 2021), the type of their work, and the reasons for remote working (Giménez-Nadal et al., 2020; Lunde et al., 2022). Mental issues related to the health emergency, such as anxiety, depression, sleep disorders, and drugs and alcohol addiction are more likely to affect healthcare workers, migrant workers, and workers in contact with the public (Giorgi et al., 2020). Other potential confounders such as work-family conflict, and managerial or organisational support might also mediate the association between workplace and mental health (Oakman et al., 2020). However, due to the availability of related data in SHARE, we were unable to consider these factors in the present study. Future studies with these factors included are needed.

Besides the above limitations, there are two unanswered questions worth addressing in future work. First, what the result is for people laid-off or involuntarily unemployed. The COVID-19 pandemic has led to high rates of unemployment across countries (Parolin, 2020). Evidence has suggested a positive association between experiencing a decreased workload and feelings of depression during the COVID-19 lockdowns, and this association was somewhat stronger among the most vulnerable socioeconomic groups (Witteveen and Velthorst, 2020). The pathway via making ends meet may be underestimated in our study, as we only included employed people. Evidence on those transferred from employed to involuntarily unemployed needs more focus in future. Second, what the specified result is for the self-employed. The data in SHARE disable us to give a further exploration, studies on this issue are also needed.

## 5. Conclusion

Using population-based and multi-national representative data, we found that working at home only or part of the time did not worsen employee's mental health, compared with only working at the usual workplace. But people working at other places (neither at the usual workplace nor home) had a higher likelihood of experiencing worse mental health. Workplace primary influenced mental health directly, and small part of the effect was explained by the indirect pathway via changing people's ability to make ends meet, the frequency of social contacting, and the chance of receiving anti-virus protection. Evidence provided in this study could contribute to more nuanced and practical public health policy strategy making, but may not generalise to younger employees or to countries or regions where remote working is not well-accepted before the COVID-19 pandemic.

## CRedit authorship contribution statement

**Shanquan Chen** had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: **Shanquan Chen**.

Acquisition, analysis, or interpretation of data: **Shanquan Chen**.

Drafting of the manuscript: **Pan Zhang and Shanquan Chen**.

Critical revision of the manuscript for important intellectual content:

**Pan Zhang and Shanquan Chen**.

Statistical analysis: **Shanquan Chen**.

Administrative, technical, or material support: **Shanquan Chen**.

Supervision: **Shanquan Chen**.

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## Role of the funder/sponsor

The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

## Reproducible research statement

Study protocol and statistical code: Available from Dr. Chen. Data set: available from <http://www.share-project.org/share-covid19.html>

## Conflict of interest

No interest needs to be reported.

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