Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Affective Disorders 295 (2021) 1335–1346

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Review article

Mass quarantine and mental health during COVID-19: A meta-analysis

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ARTICLE INFO

Keywords:
COVID-19
Mental health
Quarantine
Meta-analysis

ABSTRACT

To reveal the complex relationships between quarantine and mental health during COVID-19, a meta-analysis was conducted involving 34 articles and a total sample size of 134,061. As the relationship between quarantine and mental health was found to be affected by the sampling objects and national factors, a random-effects model was applied for the meta-analysis. First, a heterogeneity test and sensitivity analysis were conducted to determine whether there was heterogeneity in the samples, after which a funnel chart, Rosenthal's Classic Fail-safe N test and Egger's test were applied to further determine whether there was publication bias in the included samples. Finally, a sub-group test was used to explore whether the sampling group and the country of origin had a moderating effect on the relationship between quarantine and mental health, which revealed that the relationship between quarantine and mental health was regulated and influenced by the sampled objects but was not affected by the country categories. The results indicated that: COVID-19 quarantine had varying impacts on individual anxiety, depression, and psychological stress; different groups had different regulatory effects on the relationship between quarantine and mental health; and country of origin had no moderating effect on quarantine and psychology.

Background: COVID-19 is the most important topic in 2020, and mass quarantine is the measures for pandemic prevention and control around the world since 2020. To explore the relationships between mass quarantine and mental health during COVID-19, a meta-analysis was conducted involving 28 articles and a total sample size of 134,061.

Method: As the relationship between mass quarantine and mental health was found to be affected by the sampling objects and national factors, a random-effects model was applied for the meta-analysis. First, a heterogeneity test and sensitivity analysis were conducted to determine whether there was heterogeneity in the samples, after which a funnel chart, Rosenthal's Classic Fail-safe N test and Egger's test were applied to further determine whether there was publication bias in the included samples. Finally, a sub-group test was used to explore whether the sampling group and the country of origin had a moderating effect on the relationship between mass quarantine and mental health.

Results: COVID-19 quarantine had varying impacts on individual anxiety, depression, and psychological stress; different groups had different regulatory effects on the relationship between quarantine and mental health; and country of origin had no moderating effect on quarantine and mental health.

Conclusions: This study employed a meta-analysis to examine the relationships between the COVID-19 pandemic mass quarantine measures and mental health factors such as anxiety, depression and stress, from which it was found that influence of quarantine on anxiety was stronger, the relationship between quarantine and mental health was affected by the sampled object, and there was no significant relationship between quarantine and country of origin in the sample population.

1. Introduction

Coronavirus-19 (COVID-19) has been a global public health crisis in 2020 (Getty et al., 2020). To isolate the COVID-19 transmission, many countries have required citizens who may have been exposed to the virus to self-isolate either at home or in professional quarantine facilities. To

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https://doi.org/10.1016/j.jad.2021.08.067
Received 16 January 2021; Received in revised form 1 August 2021; Accepted 25 August 2021
Available online 2 September 2021

control community spread of the pandemic, China promulgated restrictive "unprecedented public health" nationwide home quarantine measures (Li et al., 2020; Wang et al., 2020). As of April, China's home quarantine initiative had received positive feedback and had been successful in curbing the COVID-19 transmission, which was consequently praised by the World Health Organization. Three months after the initial outbreak, many people in many countries were still unable to work or exercise as normal, and the pandemic had not only resulted in significant global deaths, but had given rise to mental health problems such as stress and anxiety in both COVID-19 patients and unaffected healthy citizens (Duan and Zhu, 2020; Roy and Tripathy, 2020). In particular, when in a long-term quarantine situation, many people developed negative emotions such as anxiety, depression, frustration, and the psychological panic caused by negative news. Therefore, from a policy point of view, understanding the impact of this pandemic on public mental health and life satisfaction (Brooks et al., 2020) and elucidating the public's mental health concerns under mass quarantine measures could provide a valuable reference for the best ways to prevent infections in countries in which the COVID-19 situation is serious.

1.1. Quarantine concept

Quarantine was first used for people with leprosy in Venice, Italy in 1127, and was widely used to deal with the Black Death in the 1300s; however, it was not until the 1600s that Britain began to isolate people with the plague (Newman et al., 2012). The traditional medical reason for isolation was to limit the activities of groups that may have been exposed to an infectious disease by separating those with the disease from those who did not have the disease to reduce the risk of infecting others (CDC 2017). To control the spread during the COVID-19 pandemic, many countries implemented home quarantine and/or social distancing. Different from traditional medical quarantine, home quarantine and social distancing required all people to self-quarantine and observe social distancing rules in specified places for a certain period of time. While medical quarantine isolates the infected from the uninfected, self-quarantine and social distancing measures seek to block the spread of disease in the community (Gensini et al., 2004). Quarantine has been used for centuries as an effective preventative measure to deal with infectious disease outbreaks such as cholera and plague (Brooks et al., 2020; TWU et al., 2003; Mandavilli, 2003; Barbera, 2001).

Large-scale public quarantine or home-isolation has had a significant effect on the public's mental health, with panic and psychological pressure being experienced each day from the media reports on the number of new cases (Rubin and Wessely, 2020). The pandemic required all cities in China to enforce large-scale quarantine, with the thousands of people returning to or leaving China also being forced to isolate themselves in domestic or state-owned facilities. There were some precedents for these types of measures; for example, during SARS in 2003, some metropolitan areas in China and Canada were isolated, and during the Ebola outbreak in 2014, whole villages in many West African countries were isolated. The use of quarantine has been proven to prevent the virus spread to varying degrees and allowed time for measures to be developed to prevent and treat the virus. However, studies on isolated people who experienced SARS or other public health crises found that the mental health impacts after quarantine varied significantly(Blendon et al., 2004; Caleo et al., 2018; Desclaux et al., 2017).

1.2. Relationship between quarantine and mental health

Quarantine is usually an unpleasant experience due to a separation from loved ones, the loss of freedom, uncertainty about the disease conditions and boredom, all of which can affect a person's mental health (Barbisch et al., 2015), with anxiety and emotional disorders being the most common problems (Prince et al., 2007). Studies have found that anxiety and depression were significantly related to the occurrence of viral diseases (Coughlin, 2012), and that large scale social quarantine can aggravate anxiety, fear of claustrophobia, feeling of a loss of control, and unfounded rumor propagation (Rubin and Wessely, 2020). In the early stages of the SARS outbreak, people reported many mental health issues, such as persistent depression, anxiety, panic attacks and even self-harm (Liu et al., 2003). Therefore, it is necessary to carefully weigh up the advantages and psychological costs of mandatory mass quarantines. While successful quarantine as a public health measure minimizes the negative impacts associated with the disease, because quarantine measures restrict and disrupt people's work and life, it impacts their mental health and life satisfaction (De Lima et al., 2020). In a study that compared the symptoms of post-traumatic stress in parents and children, it was found that the post-traumatic stress in isolated children was four times greater than in non-isolated children and 28% of the isolated parents reported mental health disorders related to psychological trauma compared to only 6% of the non-isolated parents (Sprang and Silman, 2013). The COVID-19 global family isolation situation of an unknown duration has resulted in increased stress, anxiety and depression and disrupted sleep (Altena et al., 2020). Limited evidence found that in a Hong Kong study the long-term social quarantine and home quarantine at the beginning of the pandemic caused the anxiety level of local people to gradually increase (Cheung et al., 2020). Previous studies have shown that when large-scale quarantines are imposed, the mental health of people experiencing the quarantine can be affected to varying degrees, with recent studies having examined the mental health differences between individuals experiencing quarantine and those not in quarantine, and the mental health of whole groups experiencing quarantine (Sprang and Silman, 2013; Bai et al., 2004; Taylor et al., 2008; Brooks et al., 2020). Therefore, Hypothesis 1 is proposed;

H1. Mass quarantine is positively correlated with the three indicators of mental health (anxiety, depression and stress).

1.3. Moderating variables for the relationship between quarantine and mental health

The correlations between quarantine and mental health can be affected by differences in the sample group. During the pandemic, because different groups had different attitudes towards the quarantine, the impact also varied. For example, because of the long-term unemployment resulting from the pandemic, many people had little to no income coming into the household, which meant that economic pressure became of the main daily sources of pressure. Recent studies have also found that workers whose incomes had been affected by the quarantine were more likely to have high levels of anxiety and depression than those whose incomes had not been affected (Taylor et al., 2008; Jeong et al., 2016). However, the mental health issues experienced by college students may have lessened because the pandemic reduced academic and competitive stress. Erickson (1994) found that with age, people's cognition and emotional experiences were more rational and less likely to be affected by the external environment. Therefore, as age assists in psychological development, in the face of a major crisis, children and adolescents are possibly not as resilient as adults. In addition, when the sample object is a mixed group, the intra-group difference can be larger. However, although the influence of irrelevant variables on demographic statistics can be controlled to a certain extent, it also has a certain influence on the research results. From this discussion, Hypothesis 2 is proposed;

H2. The relationship between mass quarantine and mental health varies in different sample groups.

Countries may also regulate the relationship between isolation and mental health. At the beginning of the outbreak, China needed to deal with the prevention and treatment of the pandemic, for which pandemic psychological assistance policies were introduced for the public. The Chinese also displayed a high degree of unity and actively cooperated with national policies on home quarantine during the pandemic. However, as different countries had different medical standards, economic levels, and anti- pandemic policies. In addition, at the beginning of the

global pandemic, China was the earliest place where the pandemic broke out, and the research on relationship between quarantine and mental health in the pandemic also focused on China, so we consider the difference between China and other countries. Hypothesis 3 is proposed;

H3. The relationship between mass quarantine and mental health is regulated by the differences between China and other countries.

This paper specifically examined the domestic home and social quarantine methods discussed in domestic and foreign studies on the mental health of isolated persons as reflected by anxiety, depression and stress levels. A meta-analysis method was employed to integrate the quarantine and mental health COVID-19 research results to explore the relationship between the quarantine, anxiety, depression and psychological stress, and discuss the moderating effect of the different sample groups and country categories on these relationships. There were three main foci for this paper based on the synthesis of the 32 studies: (1) analyze the relationships between mass quarantine and mental health problems in general; (2) assess the possible structural differences in the relationships between mass quarantine and mental health problems in different groups; (3) determine whether the relationships between quarantine and mental health problems varied by the differences between China and other countries.

2. Methods

2.1. Literature Search

This study mainly explored the effects of mass quarantine on mental health, which is different from traditional isolation. The quarantine referred to in this paper refers to the self-isolation of the majority of the population, and maintaining social distance for a certain period of time in a specific place, or still in quarantine. The quarantines explored in this study were also mainly large-scale (similar to a blockade) quarantines aimed at blocking the spread of the disease (Gensini et al., 2004). Therefore, for the article identification, large-scale quarantine and quarantines that had psychological impacts on the masses were the main search foci.

Using various search strings related to quarantine (for example, “quarantine” and “isolation”) and mental health (for example, “mental health” and “influence”), Chinese and English language studies published from December 2019 to October 2020 were searched for in the MEDLINE, EBSCO, ScienceDirect, Web of Science, and ProQuest master’s thesis full-text databases. With COVID-19, quarantine, mental health, and psychological impact as the key words in combination with stress, anxiety, depression, and negative emotion, the first search was then supplemented with a search on Google Scholar. To avoid any omissions, the references from these reviews and related articles were then manually searched. The Chinese National Knowledge Infrastructure (CNKI) and the Wan Fang databases and the VIP periodical network were also manually searched through the references, with the keywords being quarantine, pandemic quarantine, home quarantine, mental health, psychological influence, anxiety, depression, stress and negative emotion. The title, abstract and full-text article comments for each article were then screened by two independent screeners over multiple steps.

2.2. Inclusion and exclusion criteria

The meta-analysis research criteria were: (1) it had to be an empirical study that reported experimental or survey data; therefore, pure theory and literature review articles were excluded; (2) it had to report at least one correlation between quarantine and mental health effects, or include other indicators that could be converted into effect quantities, such as *OR, t, F, M±SD* etc.; (3) the samples between studies had to be independent; if the samples between studies were repeated or overlapped, the more detailed or larger samples were adopted; (4) if the dissertation was published in an academic journal, the published journal paper prevailed; and (5) the sample sizes had to be clear.

2.3. Document coding

The studies included in the meta-analysis were coded as follows: study information (author’s name & date), sample size, subject population, country, and outcome variables (stress, anxiety, and depression). The study effect values were coded based on each independent sample; if a paper reported multiple independent samples at the same time, they were coded separately to identify the multiple independent effects values. The same coder was used to recode all examined studies at different time periods, with the final comparison finding no differences between the two encoding methods.

2.4. Meta-analysis process

2.4.1. Calculation of effect size

CMA3.0 (Comprehensive Meta-analysis 3.0) specialized software was used for the meta-analysis, which uses the correlation coefficient as the effector to integrate the relationship between Quarantine and Mental Health. The weights were calculated based on the sample size and a 95% confidence interval.

The effect size *r* was calculated as follows,

$$E_{S_r} = r; w_{Z_r} = n - 3$$

$$ES_{Z_r} = 0.5\log_e\left[\frac{1+E_{S_r}}{1-E_{S_r}}\right];$$

$$SE_{Z_r} = \frac{1}{\sqrt{n-3}}$$

Many of the group design or paired design studies reported the mean value M and the standard deviation SD to compare values before and after the intervention, and some directly reported the standardized mean value *Cohen’s d* as the effect size. Therefore, these discrepancies were unified to the effect size *r* using the following formula:

$$Cohen'd = \frac{\overline{X}_1 - \overline{X}_2}{S_{within}}$$

$$S_{within} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}}$$

The normalized mean difference (*d*) was converted into a correlation coefficient I using the following formula:

$$r = \frac{d}{\sqrt{d^2+a}}$$

$$a = \frac{(n_1+n_2)^2}{n_1 n_2}$$

It was found during the coding process that some studies did not directly report the correlation coefficient between quarantine and mental health, but reported *F, T,* or X^2 values; therefore, these were converted into *r* values (Borenstein et al., 2009), that is $r = [t^2/(t^2+df)]^{1/2}$, $df = n_1 + n_2 - 2$; $r = [F/(F+df)]^{1/2}$, $df = n_1 + n_2 - 2$; $r = [\chi^2/(\chi^2+N)]^{1/2}$, with the final result being an *r* value transformed by the fisher Z.

2.4.2. Model selection and heterogeneity test

Meta-analyses either adopt fixed effect or random effect models. However, the fixed effect model assumes that there is a true effect quantity in all studies, includes only the sample involved in the study, and cannot be extended to other populations, and the random effect model assumes there is only one true effect quantity due to the different research groups and research tools (Borenstein et al., 2009)(). As the meta-analysis in this study found that the relationship between

quarantine and mental health could have been affected by the sampling object and country factors, the random effects model was considered more appropriate (Borenstein et al., 2009)().

A heterogeneity test was applied to further verify the rationality of the random effect model selection. Heterogeneity tests include Q, I^2, and H tests; the Q test is based on total variation and assumes that the effect quantity obeys chi-square distribution, that is, if $p < 0.05$, there is significant heterogeneity; the I^2 test reflects the proportion of the true effect quantity variation in total the variation, with I^2 values of 25, 50 and 75% generally regarded as the low, medium and high heterogeneity boundaries (Higgins et al., 2003);and the H-test is the correction value for the Q-effect, with $H^2 > 1.5$ indicating a high heterogeneity between the studies.

2.4.3. Publishing bias

Publication bias means that the published research literature does not systematically or comprehensively represent the completed research in the field (Rothstein et al., 2006). While the most effective way to eliminate publishing bias is to increase the sample size, the lack of representativeness in the samples and especially the lack of insignificant research results or unpublished dissertations may affect the reliability of the meta-analysis results. Therefore, this study sought to identify as many unpublished studies as possible in the literature search stage and then used funnel plot, Rosenthal's Classic Fail-safe N test, and Egger's test in the meta-analysis stage to further test for the publishing bias.

3. Results

3.1. Screening and coding results

Initially, 4,513 studies were retrieved, all of which were screened by two screeners, the flowchart for which is shown in Fig. 1. Finally, 28 studies; 21 in English and 7 in Chinese; were included in the meta-analysis, from which 55 independent effect sizes were obtained. 22 articles had anxiety as the outcome variable; 19 articles had depression, and 14 had stress.

Table 1 shows that there were 11 studies on adults (39%), 10 studies with mixed groups (36%), 4 studies on college students (14%), and the remaining 3 studies on children (11%), with most samples being from China (75%). The tools measuring the relationships between the pandemic quarantine and mental health were not unified, with 22 different scales/indices or questionnaires being used to the measure the anxiety, depression or stress levels. There were 22 effect values between quarantine and anxiety, 19 between quarantine and depression, and 14 between quarantine and stress, with 15 articles reporting a significant correlation between quarantine and anxiety (Fig. 2), 15 articles reporting a significant correlation between quarantine and depression (Fig. 3), and 10 articles reporting a significant correlation between quarantine and stress (Fig. 4).

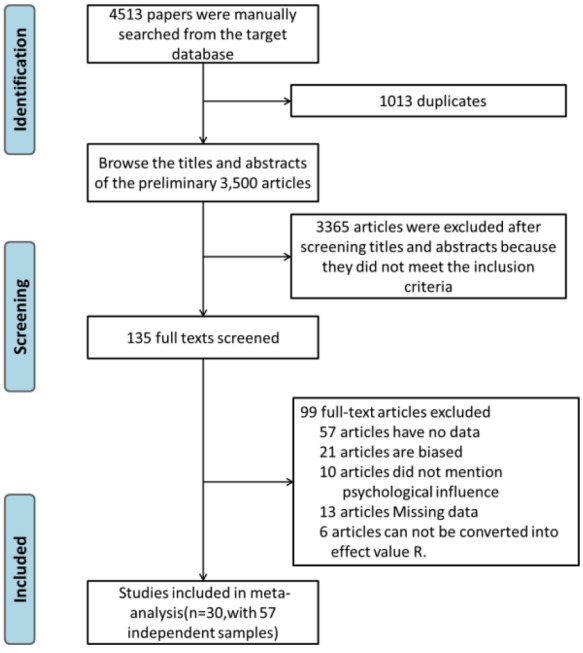

Fig. 1. Flow chart of document retrieval process.

3.2. Publishing bias test

A funnel plot test was first used to check the meta-analysis publication bias, as shown in Fig. 5, from which it was found that there were no serious publication biases in the relationships between quarantine, mental health, and its indicators. However, the funnel chart was only intended to be a preliminary examination; therefore, the more accurate Rosenthal's Classic Fail-safe N and Egger's Tests were then conducted (see Table 2).

Table 2 shows that the Fail-safe N for quarantine and anxiety, depression and stress were respectively 3259, 2064 and 1407, that is, additional studies were needed to negate the important relationships between quarantine and mental health and its indicators. The corresponding ratios for the four insecurity factors were all much greater than one, which indicated that the sample was representative and there were no publication deviations. The p values for the Egger's Intercept in the three result variables were respectively, 0.24, 0.39, and 0.19, which were not significantly different from zero ($p > 0.05$), which also indicated that there were no publication biases in the quarantine and mental health associations.

3.3. Heterogeneity test

Table 3 shows the results of the heterogeneity tests between the quarantine, mental health and subgroup relationships. The *Q*-test for the effect values between the studies was significant ($p < 0.001$), that is, the meta-analysis effect values were heterogeneous. The *I-squared* value was between 86.01 and 87.70%, which indicated that the true variation for the effective quantity accounted for 86.01 and 87.70% of the total variation, and that random error accounted for only a small proportion. Form Higgins et al. (2003) to judge heterogeneity, it indicated that there is heterogeneity, which showed that it was appropriate to choose random effect model for the next analysis; An *H-squared* > 1.5 also indicated heterogeneity between studies, the formula for which was *H-squared*=*Q*/(*K*-1). The results also suggest that the difference of estimated values between different studies may be interfered by some research characteristics, and a reasonable discussion can be made on the moderating variables that affect the relationship between isolation and mental health. The Tau-squared value was found to be between 8 and 12%, that is, 8%~12% of the effect quantity variation between the different studies could be used to calculate the weights.

3.4. Sensitivity analysis

The heterogeneity test found that the effect values in each study were highly heterogeneous. Therefore, based on the funnel chart and deviation of effect values, a sensitivity analysis was conducted on the heterogeneity effect of the relationships between quarantine and mental health.

After analyzing the 26 studies using the One-study removed function, it was found that one study (Li et al., 2020) had possible extreme values. After this was deleted, the anxiety heterogeneity decreased to 78.59%, and the quarantine and anxiety effect was $r = 0.10$, $P < 0.001$. Using the One-study removed function, 20 studies were gradually deleted and analyzed, from which one studies (Li et al., 2020)(Ng, 2020) had possible extreme values. After these were deleted, the depression

Table 1
Contains 28 basic data of meta-analysis studies.

Study	Total sample N	Group	Country	Measure	Outcome	Effect size CorrelationI
Bai (2020)	420	Children	China	Conners parental rating questionnaire	Anxiety	-0.258
Zhang Xindan (2020)	706	College students	China	SBS Questionnaire	Stress	0.083
Li et al., 2020	396	Children	China	SCARED	Anxiety	0.761
Ma et al., 2020	123	Adults	China	DASS	Stress & Anxiety & Depression	0.057 & 0.025 & 0.164
Chen and Song, 2020	127	Mixed	China	SCL-90	Anxiety & Depression	0.174 & 0.067
Li C. Y. et al., 2020	378	Mixed	China	DASS - 21	Stress & Anxiety & Depression	0.529 &-0.025 & 0.642
Zanardo et al. (2020)	192	Adults	Italy	EPDS	Anxiety & Depression	0.103 & 0.226
Lu et al. (2020)	1849	Adults	China	CES-D	Depression	0.060
Wang et al. (2020a)	1738	Mixed	China	IES-R & DASS-21	Stress & Anxiety & Depression	0.051 & 0.070 & 0.060
Lei (2020)	1593	Mixed	China	SAS & SDS	Anxiety & Depression	0.112 & 0.118
Guo (2020)	2331	Adults	China	HADS	Anxiety & Depression	0.017 & 0.017
Shi et al. (2020)	56679	Adults	China	PHQ-9 & GAD-7	Stress & Anxiety & Depression	0.070 & 0.068 & 0.072
Rossi et al. (2020)	18147	Adults	Italy	PHQ-9 & GAD-7	Stress & Anxiety & Depression	0.096 & 0.115 & 0.109
Xu (2020)	2322	Mixed	China	PHQ-9 & GAD-7	Anxiety & Depression	0.296 & 0.284
Casagrande (2020)	2291	Adults	Italy	GAD-7 & PGWB	Stress & Anxiety	0.299 & 0.172
Baiano et al. (2020)	25	College students	Italy	PSWQ & ASI-3	Stress & Anxiety	0.095 & 0.360
Khan et al. (2020)	505	College students	Bangladesh	DASS - 21	Stress & Anxiety & Depression	0.063 & 0.010 & 0.055
Gan (2020)	3233	Mixed	China	MHRPHES & PSS-10	Stress & Anxiety & Depression	0.107 & 0.086 & 0.115
Xin et al. (2020)	24378	Mixed	China	PHQ-9	Stress & Depression	0.065 & 0.065
Liu (2020)	455	Mixed	China	STAI & SDS	Anxiety & Depression	-0.177 & -0.192
Rosen et al,. 2020	303	Adults	America	BAI	Anxiety	0.230
Tang et al. (2020)	1160	Adults	China	CES-D-20 & GAD-7	Depression	0.284
Zhu (2020)	2279	Adults	China	SRQ-20, GAD-7, & PHQ-9	Stress & Anxiety & Depression	0.022 & 0.016 & 0.015
Zhao (2020)	2003	Mixed	China	BAI	Anxiety	0.651
Peng et al. (2020)	2237	Adults	China	SAS	Anxiety	0.078
Tang et al. (2020)	2485	College students	China	PHQ-9	Depression	0.021
Wang et al. (2020b)	1210	Mixed	China	DASS-21	Stress & Anxiety & Depression	0.045 & 0.032 & 0.045
Saurabh and Ranjan (2020)	252	Children	India	N/A	Stress	0.226

In order to reduce the space, only the first author is listed. PHQ-9,the Patient health Questionnaire-9; GAD-7,Generalized Anxiety Symptoms: the General Anxiety Disorder questionnaire; PGWB, the Psychological General Well-Being questionnaire; DASS-21,the Depression, Anxiety and Stress Scale; ASI-3, Anxiety Sensitivity Index; PSWQ, Penn State Worry Questionnaire; EPDS,the Edinburgh Postnatal Depression Scale; CES-D, the Center for Epidemiological Studies Depression; IES-R, the Impact of Event Scale-Revised; EFA, Exploratory factor analysis; SAS, the self-rating anxiety scale; SDS, the self-rating depression scale; HADS, the 14-item Hospital Anxiety and Depression Scale; PSS, the 10-item Perceived Stress Scale; MHRPHES, The Mental Health Response to Public Health Emergency Scale; STAI, the State-Trait Anxiety Inventory; CES-D-20, The Center for Epidemiological Studies Depression Scale; SCARED, the Screen for Child Anxiety Related Emotional Disorders; SCL-90, Clinical Symptoms Self-rating scale.

heterogeneity reduced to 76.70%, and the quarantine and depression effect was $r = 0.09$, $p < 0.001$. Using the One-study removed function, 18 studies were gradually deleted and analyzed, and two studies (Casagrande et al., 2020; Li et al., 2020) found to have possible extreme values. After the consequent deletions, the psychological stress heterogeneity was reduced to 70.16%, and the effect of the quarantine and stress relationship was $r = 0.08$, $p < 0.001$. The above results showed that regardless of the heterogeneity degree, there was a significant correlation between quarantine and mental health.

3.5. Main effect test

The correlations between quarantine and the three mental health indicators; anxiety, depression and stress; were estimated using the random effects model, with the correlation coefficients for quarantine and anxiety, quarantine and depression, and quarantine and stress being 0.152, 0.115 and 0.125, $p < 0.001$. From Cohen (1988) reference criteria for the interpretation of correlation coefficient sizes, $r \leq 0.1$ was considered a small effect size, r=0.25 was considered a medium effect size, and $r \geq 0.4$ was considered a large effect size. As the correlation coefficient between quarantine and mental health was found to be between 0.1 and 0.25 in this study, a moderately weak positive correlation was found. However, because the Cohen coefficient was based on qualitative analyses, it can be highly subjective. Therefore, after consulting Gignac and Szodorai (2016), which systematically and quantitatively analyzed the correlation sizes in 708 meta-analysis reports on individual differences, the low, medium, and strong correlations were set at $r = 0.1$, $r = 0.2$ and $r = 0.3$. Based on these criteria, the correlation coefficients between quarantine and mental health ranged from 0.1 to 0.2, which indicated a moderate positive correlation, that is, quarantine was positively correlated with anxiety, depression and stress.

3.6. Subgroup test

The heterogeneity test showed that the effect values in each study were highly heterogeneous and that there may have been significant regulatory variables. Therefore, a subgroup test was applied to explore the heterogeneity sources and the regulation of the research

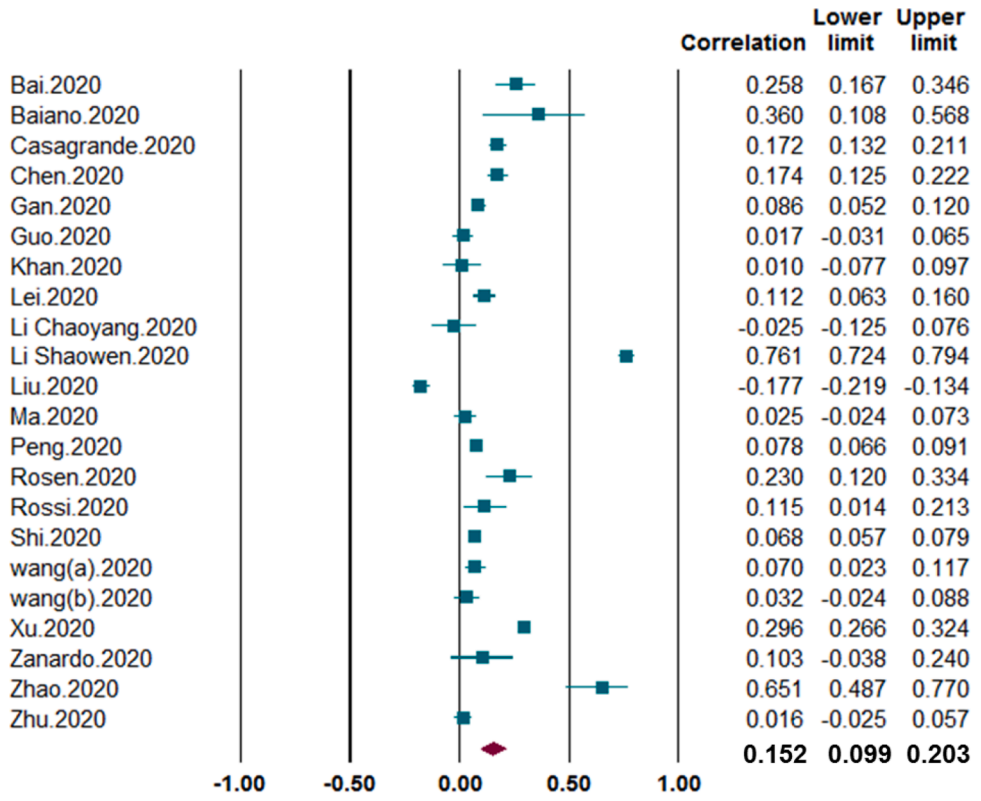

Fig. 2. Forest plot of quarantine and anxiety.

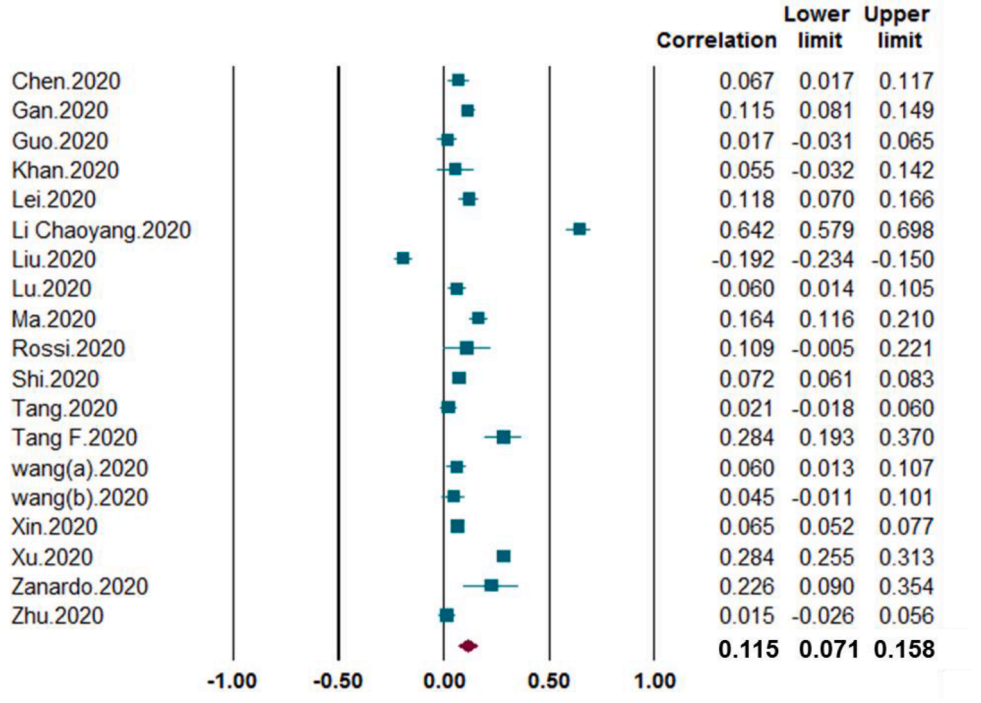

Fig. 3. Forest plot of quarantine and depression.

characteristics on the effect quantity, with a specific focus on the moderating effects of the sample groups; children, adults, mixed groups, college students; and countries; China, Italy, and others; on the relationship between quarantine and mental health (Tables 4 and 5).

Table 4 shows that the Sample Groups were significantly adjusted for anxiety (Q_b =3.22, $p < 0.05$), depression (Q_b =9.37, $p < 0.05$) and stress (Q_b =6.10, $p < 0.05$). Of these, the relationships between quarantine and mental health and the other indices in the mixed population were found to be relatively high. As there were fewer than two articles on children and adolescents with depression and stress outcome variables, these were removed from the regulatory effect group analysis on the relationship between quarantine and the three mental health variables.

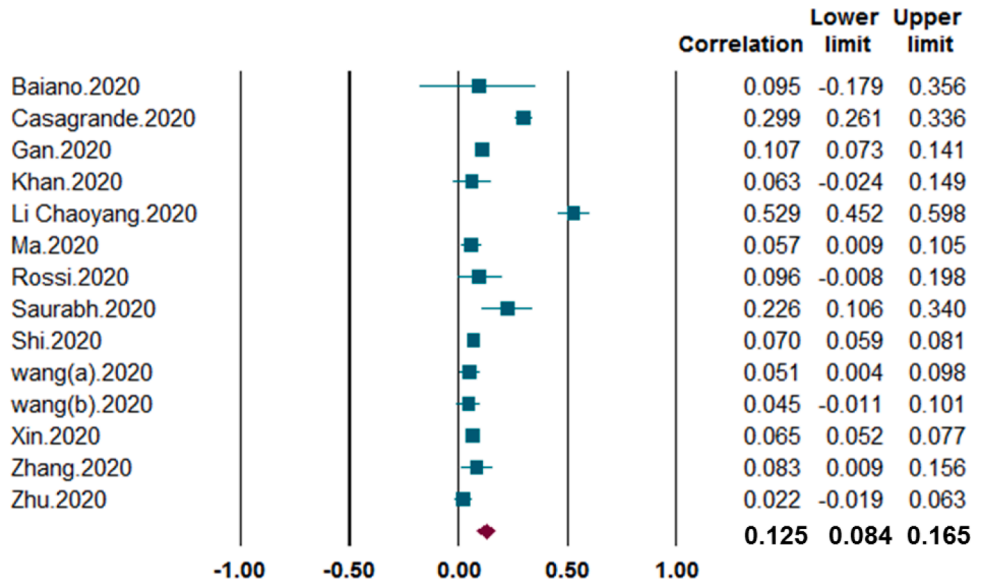

Fig. 4. Forest plot of quarantine and stress.

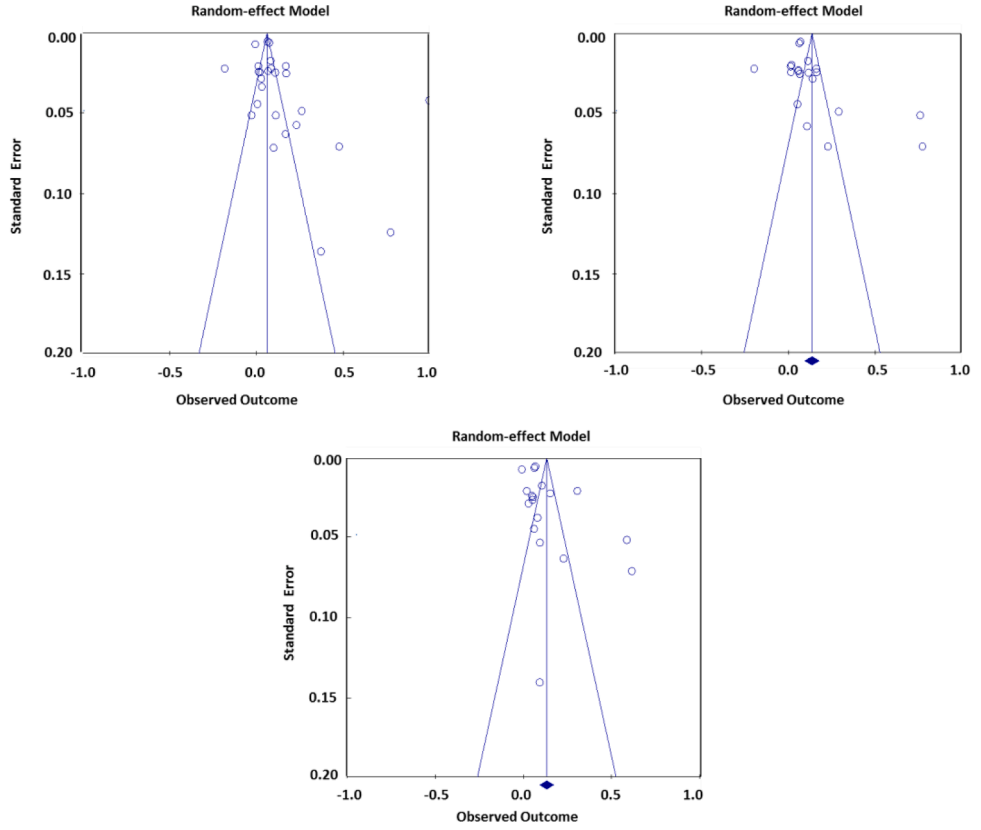

Fig. 5. Funnel plots for quarantine and anxiety (top left), quarantine and depression (top right), and quarantine and stress (bottom right).

Table 2
Test results of publication bias.

Outcome	*K*	*Classic Fail-safe N*	*FSR*	Egger's Intercept	*SE*	*LL*	*UL*	*p*
Anxiety	22	3235	22.74	2.56	2.04	-1.69	6.81	0.22
Depression	19	2064	20.52	1.81	2.03	-2.48	6.10	0.39
Stress	14	1330	19.20	2.29	1.59	-1.18	5.76	0.18

Note: LL and UL represent the lower and upper limits of the 95% confidence interval of Egger's regression Intercept.

Table 3
Heterogeneity test results.

Outcome	*K*	*Q*	*df*	*p*	I^2	τ^2	H^2
Anxiety	22	177.64	21	<0.001	87.44	0.12	8.16
Depression	19	136.99	18	<0.001	86.86	0.04	7.61
Stress	14	107.95	13	<0.001	87.18	0.01	7.76

Table 5 shows that there were significantly positive correlations between quarantine and anxiety, depression and stress in the different countries and that the weighted *r* value was relatively stable at a 95% confidence interval. The country effects on the relationships between quarantine and mental health were compared: anxiety ($Q_b = 0.18$, $p > 0.05$), depression ($Q_b = 0.58$, $p > 0.05$), and stress ($Q_b = 1.11$, $p > 0.05$). There were no significant differences found between the two groups, that is, the relationships between quarantine and anxiety, depression, and stress did not vary by country.

4. Discussion

4.1. Quarantine and mental health

The mass quantitative meta-analysis revealed that there was a significant relationship between quarantine and mental health during the COVID-19 pandemic (r=0.13, p<0.001), and hypothesis 1 is verified, with the longer the quarantine time, the higher the anxiety, depression and stress levels, which was consistent with many recent pandemic studies(Brooks et al., 2020; Chen and Song, 2020a; Gan et al., 2020; Ozamiz-Etxebarria et al., 2020; Wang et al., 2020b; Zhang and Chang, 2020). The relationship between quarantine and anxiety was identified in many studies (Li et al., 2020; Jeong et al., 2016; Baiano et al., 2020; Casagrande et al., 2020; Zhao et al., 2020) and the meta-analysis found that compared with other mental health factor measurements, quarantine had the highest correlation with the anxiety factors (r=0.152, $p <$ 0.001, see Fig. 2), with the longer the quarantine time, the higher the anxiety level. Studies from SARS to COVID-19 found that home isolators' anxiety increased because the reports on the daily increases in the number of confirmed cases and deaths, their lack of knowledge about the disease, and the effects of anxiety in other people close to them made them believe that they or their family members were at risk of contracting the disease or even dying at any time (Cheng et al., 2004; Maunder et al., 2003; Li et al., 2020). People living alone were found to have an increased risk of anxiety symptoms, possibly due to reduced social interactions during quarantine (Lei et al., 2020), at which time they could also experience fear, depression, and boredom, which could be further exacerbated by interruptions in information flows (Thienkrua and Warunee, 2006; Cheng et al., 2004). However, some studies also commented that while social media was able to provide up-to-date information during the quarantine/isolation period, social media's "always online" situation could exhaust people and damage mental health, with high-risk negative social media information possibly contributing to heightened anxiety (Xiang et al., 2020; Purohit et al., 2018). The results of this study did not support (Bai et al., 2020; Al Sulais, 2020; Liu, 2020), who all found that anxiety levels decreased with quarantine time.

The meta-analysis showed that there was also a certain correlation between quarantine and depression ($r = 0.115$, $p < 0.001$, seeFig. 3), which was consistent with previous studies (Ma et al., 2020; Jalloh et al., 2018; Cheng et al., 2004). After some time in quarantine, changes in a person's physiological activities such as diet, sleep quality and physical exercise could increase depression levels (Wang et al., 2020; Chew et al., 2020). Previous studies also identified a correlation between a perception of physical health and depression (Hossain et al., 2019). Another explanation could be that because social quarantine reduces interpersonal communication, people may feel lonelier, which could lead to heightened feelings of depression (Ge et al., 2017; Weiss, 1973). During the SARS pandemic, studies also found that people who isolated had higher depression levels (Chih-Hung et al., 2010).Wang (2020)found that ordinary people without formal education were more likely to suffer from depression in a study on the immediate psychological responses of the general population in China at the beginning of the COVID-19 pandemic, and Lei et al. (2020) found that high depression levels were associated with a lack of psychological support or counseling from the community or government agencies. However, several studies found that people with depressive symptoms tended not to ask for help (Lienemann and Siegel, 2019; Rickwood et al., 2005) because of shame or embarrassment, with their determination to look after themselves being a barrier to seeking help (Gulliver et al., 2010). Therefore, raising public awareness about these types of mental disorders could greatly assist in encouraging people to seek help (Suka et al., 2020). Tang et al. (2020)

Table 4
The moderating effect of sampling group on the relationship between quarantine and mental health.

Outcome	Group	*K*	*r*	95% *CI*	I^2	Q_w	Q_b	*P*
Anxiety	Adults	9	0.08	0.05-0.10	83.92	49.74***	3.22	0.041
	College students	2	0.17	-0.18-0.48	84.59	6.49*		
	Children	2	0.56	-0.09-0.88	96.44	28.09***		
	Mixed groups	9	0.13	0.02-0.23	95.01	672.18***		
Depression	Adults	8	0.10	0.06-0.15	86.60	52.22***	9.37	0.009
	College students	2	0.03	-0.01-0.06	0	0.49		
	Mixed groups	9	0.14	0.05-0.23	92.46	106.10***		
Stress	Adults	5	0.11	0.02-0.20	93.90	66.67***	6.10	0.039
	College students	3	0.08	0.02-0.13	0	0.14		
	Mixed groups	5	0.15	0.07-0.24	93.13	61.03***		

Note: Q_w indicates intra-group heterogeneity; Q_b represents heterogeneity between groups; ***$p < 0.001$,** $p < 0.01$;*$p < 0.05$. The table below for the same reason.

Table 5
The moderating effect of countries on the relationship between quarantine and mental health.

Outcome	country	*K*	*r*	95% CI	I^2	Q_w	Q_b	*P*
Anxiety	China	16	0.15	0.09-0.21	94.11	254.67***	0.18	0.68
	Developed countries	5	0.17	0.12-0.22	77.02	27.58		
Depression	China	16	0.11	0.07-0.16	94.28	262.24***	0.58	0.448
	Developed countries	2	0.16	0.05-0.27	41.34	1.71		
Stress	China	9	0.10	0.06-0.13	92.93	113.10***	1.11	0.58
	Developed countries	3	0.18	0.01-0.35	86.95	15.32***		
	Developing countries	2	0.14	-0.02-0.30	78.55	4.66*		

found that there was no correlation between long-term family quarantine and depression; however, this study was conducted only one month after COVID-19 broke out and there was little longitudinal mental health evidence available.

A significant relationship between quarantine and mental stress was found (r=0.125, p<0.001, see Fig. 4), which was consistent with many of the examined studies (Lei et al., 2020; Mullen and Smyth, 2004). It was also found that people who were forcibly isolated were more likely to suffer from discrimination and exclusion by neighbors and other groups, with quarantine stigma being found to be very common (Karamouzian and Hategekimana, 2015), which in turn could aggravate an isolated person's stress and result in mental health deterioration (Robertson et al., 2004). The social marginalization and exclusion associated with this stigma was also observed to damage both emotional and physical health (Goffman, 1963; Mullen and Smyth, 2004; Twenge and Crocker, 2002). Long-term quarantine was found to lead to an increase in the frequency of family conflicts, with these family conflicts being one of the key stressors for consequent mental health problems (McCloskey et al., 1995). Some studies also found that although there was some evidence that the quarantine experience was negatively related to mental health, quarantine could also have beneficial psychological effects as it reduced the risk of infection and the fear of being infected (Locke et al., 2019; Al Sulais et al., 2020).

Overall, most studies on the COVID-19 pandemic reported a significant relationship between short-term quarantine and increases in individual stress, anxiety and depression levels. However, a small number of articles found no significant or negative correlations between quarantine and mental health. For example, Wang et al. (2020) focused on the relationship between length of stay at home and anxiety, depression and stress in the initial and peak outbreak periods, and found that the length of time spent at home was not related to anxiety, depression, stress or PTSD symptoms four weeks after the initial outbreak; Guo et al. (2020), Tang et al. (2020) and Zhu (2020) reported similar results. This could possibly be explained by the "psychological typhoon eye effect", which describes the psychological response to disasters using the meteorological typhoon eye phenomenon, that is, the air around the typhoon rotates violently, while the air inside the typhoon is relatively weak. Similarly, the closer the time period was to the high-risk stage, the calmer the individuals appeared to be (Li et al., 2009; Liang et al., 2008; Lindell and Earle, 1983; Maderthaner et al., 1978). This phenomenon was verified by many of the pandemic studies (Bai et al., 2020; Liu et al., 2020). A similar phenomenon was observed during the SARS pandemic in Hong Kong, when it was found that the anxiety of the residents in the pandemic areas was lower than the residents in the non-pandemic areas (Xie et al., 2003).

4.2. Regulatory effect of quarantine and mental health

4.2.1. Sample group effects

The meta-analysis found that the sample groups were also the moderators for quarantine and anxiety (Q_b =3.22, $p < 0.05$), depression (Q_b =9.37, $p < 0.05$), and stress (Q_b =6.10, $p < 0.05$), and hypothesis 2 is verified. When the sample was a mixed group, the quarantine had the highest regulatory effect on anxiety, depression and stress; when the result variable was anxiety, the regulatory effect on children and adolescents was second only to the mixed group and the regulatory effect on adults and college students was equal; when the result variable was depression, the adjustment effect on college students as a sample group was the weakest; and when the result variable was stress, the adjustment effect on adults was higher than on college students. The main reason for these differences was that when the sample population was a mixed population, the study population was more extensive and complex, and the organization more dispersed. Because of the heterogeneity and sample object differences, the research results varied (Li, 2003; Rao, 2005). Children were found to have a stronger moderating effect on anxiety than the adults or college students, which was related to the age and psychological development. Erikson (1994) noted that with an increase in age, as individual cognition and emotional experience are more rational, people are less likely to be influenced by the external environment. Previous studies have found that crisis events can cause more serious psychological trauma in children than in adults (Alisic et al., 2011; North et al., 2018). The moderating effect of being an adult on the three outcome variables was found to be generally higher than for college students because the different adult ages and types impacted the research results. Previous studies have shown that different ages, genders, occupations, etc. have different effects on psychological statuses (Huang and Zhao, 2020). For example, it has been found that the higher the education level of college students, the greater the degree of negative emotions (Li et al., 2020). Due to the influence of the quarantine, normal education and teaching activities were hindered, which may have been one of the reasons the college students felt under greater pressure, that is, the uncertainty regarding their academic progress may have been a significant stressor for young people (Roy et al., 2020).

4.2.2. Country

The meta-analysis found that country of origin had no moderating effect on the relationship between quarantine and mental health, and hypothesis 3 is not supported. This may have been because the COVID-19 pandemic is a global public health crisis and the mental health issues resulting from the anti-pandemic quarantine measures were common to all countries (Banerjee and Rai, 2020; Remuzzi and Remuzzi, 2020). Most of the reviewed articles reported depression, anxiety, emotional disorders, psychological stress, post-traumatic stress, insomnia, fear, stigmas, low self-esteem, lack of self-control and other adverse mental health consequences during the social quarantine period (Giallonardo et al., 2020; Luo et al., 2020; Nussbaumer-Streit et al., 2020; Röhr et al., 2020). Because the virus appeared in China first, the Chinese government were the first to adopt rapid and effective quarantine measures to ensure citizen security, and after the quarantine ensured that the public were aware of the COVID-19 situation. Psychological assistance systems were also established as soon as possible to alleviate the negative emotions in the public as much as possible (de Lima, 2020; Song, 2020). In other countries, during and after the quarantine period, many measures were rapidly adopted to alleviate any continuing mental health problems (Ng, 2020; Kang et al., 2020; Pieh et al., 2020).

4.3. Limitations and future research

Limitations: (1) Because the meta-analysis method requires that both published and unpublished studies, conference reports and network reports be included in the literature retrieval, it was inevitable that some data were missing due to restrictions such as encryption, incomplete databases and difficulty in contacting the authors of articles. (2) This study did not assess the moderating effects of gender, quarantine time, measuring tools, or other factors on the relationship between quarantine and mental health. In previous studies, the longer the quarantine time, the higher the level of anxiety and psychological stress; however, this level of anxiety was found to decrease after 4–6 months of quarantine (Jeong et al., 2016). (3) Few studies on the relationship between quarantine and the mental health of children and adolescents were included, which made it difficult to explore the regulatory effect of quarantine on the relationship between depression and psychological stress in these groups. (4) The lack of relevant literature from some countries and the very few or no studies in some countries may have impacted the moderating effect results for country on the relationship between quarantine and mental health. (5) The paper mainly referred to mass quarantines and the results can be different for individual level quarantines.

Therefore, future research could: (1) pay attention to quarantine time on the relationship between quarantine and mental health to more comprehensively explain the relationship between quarantine and mental health; (2) explore relevant literature on the relationships

between quarantine and mental health in children and adolescents; (3) collect Chinese and English documents more systematically and comprehensively and seek a better balance; (4) unify the measurement tools to better extract comparative relationships between quarantine and stress, anxiety and depression. and (5) explore the difference between mass quarantine and individual level quarantines, and make a comparative analysis of them.

Funding

The research is supported by the Ministry of Education of Humanities and Social Science Project of China (20YJA880023) and Sichuan Social Science Planning project "Major projects of key research bases" (SC19ZD052), "Double Major" cultivation projects of Sichuan Normal University (2021-SZPY-04). We appreciated this support both in finance and in spirit.

CRediT authorship contribution statement

Yuchang Jin: Conceptualization, Writing – review & editing. **Tengwei Sun:** Methodology, Formal analysis, Writing – review & editing. **Peixuan Zheng:** Conceptualization, Writing – review & editing. **Junxiu An:** Methodology, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The author declares no conflict of interest. The manuscript is approved by all authors for publication.

Acknowledgments

The research is supported by the Ministry of Education of Humanities and Social Science Project of China (20YJA880023) and Sichuan Social Science Planning project "Major projects of key research bases" (SC19ZD052), "Double Major" cultivation projects of Sichuan Normal University (2021-SZPY-04). We appreciated this support both in finance and in spirit.

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