Mental burden and its risk and protective factors during the early phase of the SARS-CoV-2 pandemic: systematic review and meta-analyses

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Abstract

Background: Mental burden due to the SARS-CoV-2 pandemic has been widely reported for the general public and specific risk groups like healthcare workers and different patient populations. We aimed to assess its impact on mental health during the early phase by comparing pandemic with prepandemic data and to identify potential risk and protective factors.

Methods: For this systematic review and meta-analyses, we systematically searched PubMed, PsycINFO, and Web of Science from January 1, 2019 to May 29, 2020, and screened reference lists of included studies. In addition, we searched PubMed and PsycINFO for prepandemic comparative data. Survey studies assessing mental burden by the SARS-CoV-2 pandemic in the general population, healthcare workers, or any patients (e.g., COVID-19 patients), with a broad range of eligible mental health outcomes, and matching studies evaluating prepandemic comparative data in the same population (if available) were included. We used multilevel meta-analyses for main, subgroup, and sensitivity analyses, focusing on (perceived) stress, symptoms of anxiety and depression, and sleep-related symptoms as primary outcomes.

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Introduction
The emergence of novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was described for the first time in Wuhan, China [1, 2] and declared a public health emergency of international concern on 30 January 2020 [3]. The virus spread rapidly and, as of January 14, 2021, led to 90,759,370 confirmed infections and 1,963,169 deaths worldwide [4].

During the early phase of the pandemic, many countries adopted drastic measures, including testing, tracing, self-isolation, and quarantine measures as well as broader population measures ranging from travel bans, school closures, assembly restrictions, curfews, to full lockdowns [5–7]. Besides substantial stressors for individuals and the general public (eg, social isolation, reduced income, re-structuring of school, university, and work life) and healthcare systems (eg, disruption of essential health services) [8, 9], the SARS-CoV-2 pandemic has had major socio-economic consequences for the affected countries (eg, global supply chain disruptions) [10, 11]. By drastically changing our way of social interaction (eg, social distancing), it continues to affect many areas of daily life and in line with this social life and participation.

The disease-related threats, containment measures, and associated stressors may have a negative psychological impact on the community at large and potentially even more so on specific risk groups [12–17]. Given the work-related stressors in the context of disease outbreaks (eg, high workload, risk of infection, triage decisions), healthcare workers may suffer from a particularly high burden [18]1,2 [20–22]. Patients with pre-existing physical or mental conditions (eg, chronically ill individuals, psychiatric patients, geriatric patients), people with confirmed COVID-19 diagnosis, those recovering from the infection, or suffering from long COVID-19, and subgroups with special risk exposure (eg, caregivers) may also be at risk of developing stress-related mental symptoms [15, 22–28].

Various systematic reviews have synthesized the evidence on psychiatric symptoms associated with previous highly contagious infectious disease outbreaks (eg, Ebola, SARS-CoV) and the SARS-CoV-2 pandemic [20, 24, 29–35], some of them also narratively summarizing risk and protective factors for mental health [20, 30, 31, 33, 34]. Several meta-analyses have been conducted, either calculating the pooled prevalence of mental symptoms or odds ratios for the risk of mental burden attributable to the SARS-CoV-2 pandemic [20, 24, 29, 32, 33, 36]. Potential moderators of the negative mental health impact were also partly investigated [32]. International evidence indicates an elevated level of mental symptoms in the general public, including symptoms of anxiety, depression, and stress [30–33, 36]. Confirming the risk status of healthcare workers, several reviews also found an increased prevalence of mental symptoms in this group [18]1,2 [20, 29, 31, 32]. Finally, a few studies in patient populations (eg, COVID-19 patients, patients with pre-existing mental or physical conditions) show increased mental burden [24, 31–33].

There are several shortcomings of reviews published to date. Most either focus on the general population, healthcare workers, or patients, with only few publications examining the level of mental burden across all three specified, most relevant population groups [31–33]. Further limitations included a limited search strategy [31], language restrictions [24, 30, 31, 33], or a missing

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1 included pandemic studies.
2 studies already considered in previous systematic review (Gilan, Röthke and colleagues) [19].
preregistration [20, 24, 29–31, 33, 36]. Most importantly, all but one systematic review failed to compare the mental burden during an ongoing pandemic with the burden before the pandemic [31]. Such comparisons, however, are necessary to quantify the mental burden specifically attributable to the current pandemic. We therefore aimed to assess the mental health impact of the SARS-CoV-2 pandemic by comparing data from the early phase of the current pandemic with prepandemic data in the general population, healthcare workers, and patients. We aimed to identify population-specific risk and protective factors for mental health.

Methods

Review registration

This systematic review [37] was preregistered with PROSPERO (registration no. CRD42020193249) with the title ‘Psychological distress, protective factors and resilience during the SARS-CoV-2 pandemic: a systematic review and meta-analysis with comparison to standard data’. Details of the methods are presented in the Additional file 1. The MOOSE Checklist for Meta-analyses of Observational Studies and differences between the protocol and the final review are presented in eTables 1 and 2.

Search strategy and selection criteria

We searched three bibliographic databases from January 1, 2019 to May 29, 2020 (PubMed, PsycINFO, and Web of Science) and inspected the reference lists of included studies. The search strategy comprised terms associated with mental health, pandemics, and the populations of interest (see eMethods 1 in Additional file 1). There were no restrictions concerning language, publication date, or publication format. We did not consider preprint articles. If not reported within a study, we systematically searched for prepandemic comparative data in the same or a similar population (PubMed, PsycINFO; see eMethods 2).

The populations of interest comprised the general population, healthcare workers, and any patients (eg, COVID-19 patients, those with pre-existing physical or mental conditions; eTable 3). Participants were included irrespective of age, health, or employment status. We did not consider infectious disease outbreaks other than due to SARS-CoV-2. To be eligible for the review, studies had to assess at least one mental health outcome, with a broad range of eligible outcomes (ie, anxiety and worrying, depression, posttraumatic stress, sleep, stress, general psychological distress). These outcomes were also considered for a descriptive synthesis of the prevalence (see data analysis). We included original research articles reporting on cross-sectional and longitudinal surveys.

All pandemic studies meeting these criteria were included but were only taken forward to pairwise meta-analyses if using a validated outcome measure and if prepandemic comparative data were available (eTables 4, 5). These were defined as data collected before the exposure to the current pandemic, and in the absence of other disease outbreaks or macro-stressors (eg, disasters), in the same country and population group (if available) and using the same outcome measure. In contrast to the review, we only focused on the four most frequently reported mental health outcomes (primary outcomes), including symptoms related to stress, anxiety, depression, or sleep. Posttraumatic stress, although reported more often than sleep, was not considered for pairwise meta-analyses. As this outcome is usually measured in the aftermath of macro-stressors, we were not able to identify adequate comparative data as mentioned above. Comparative data were selected stepwise using four levels to ensure best available comparability between SARS-CoV-2 exposure (‘pandemic’) studies and prepandemic (‘comparative’) studies. If representative studies in the same country and population (level 1) were not available, we used prepandemic studies in the same (level 2) or an alternative population (level 3; eg, healthcare workers compared with the general population), before resorting to the best available data in a similar country (level 4).

Study selection, data extraction, and quality assessment

The study selection process for the pandemic studies at the level of titles/abstracts and full-texts was performed in duplicate by two reviewers independently (NR, LG). Any disagreements were resolved by discussion or by consulting a third reviewer (KL). At both title/abstract (κ = 0.90) and full-text level (κ = 0.97), excellent interrater reliability was achieved.

Relevant information for each included study was extracted in duplicate by two reviewers (NR, LG), working independently, using a customized spreadsheet (eTable 6), which was shortened for the extraction of comparative data. Discrepancies were resolved through discussion or by a third reviewer (KL).

Three independent reviewers (NR, JSW, LG) assessed the quality of included studies using the modified National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [38] (eTable 7), with disagreements being resolved by discussion or a third reviewer (KL). The level of comparability between pandemic and comparative data was assessed using a self-developed tool with four levels based on the previously mentioned levels for the stepwise selection of comparative data (eTable 8).
Data analysis
The included studies were synthesized in narrative and tabular form, with a descriptive analysis of prevalence rates for mental health symptoms (i.e., proportion of participants beyond a cut-off score reported in the included study) and of risk and protective factors. If adequate comparative data for any of the primary outcomes were available, pairwise meta-analyses were performed for the general population, healthcare workers, and patients, respectively (eMethods 3). Given the multiple uses of comparative studies, we used multilevel meta-analyses [39] for the general population and healthcare workers, with pandemic studies being clustered according to pre-pandemic comparators. For patients, the multilevel model reduces to the classic random-effects model as different comparative studies were available. Prediction intervals were calculated in meta-analyses with at least four studies to take the large between-study heterogeneity into account [40].

Two sensitivity analyses referred to the quality of pandemic studies and the level of comparability (see Search strategy and selection criteria), by limiting the analyses to very comparable pandemic and pre-pandemic studies (i.e., level 1 and 2 mentioned above).

Subgroup analyses for each of the three groups were performed for the surveyed populations (e.g., age), characteristics of the pandemic studies (e.g., survey start) and of comparative data (e.g., publication year), and the relationship of sample sizes in pandemic versus comparative studies, in order to identify potential sources of heterogeneity of the psychological impact of the SARS-CoV-2 pandemic.

Results
Details of the results are presented in the Additional file 2. The systematic search for studies performed during the SARS-CoV-2 pandemic identified 2429 records from database searches and 17 additional records from reference lists, of which 104 studies were included in the review and 43 studies in the meta-analyses (Fig. 1). Of the 104 eligible studies, most studies were performed in the general population (50 studies), followed by 30 studies in healthcare workers, and seven studies in various patient populations. Seventeen studies included mixed samples. Across the three population groups, a total of 208,261 participants ranging from 51 to 52,730 participants [41, 42]1 from the pandemic studies were included in the review, the number of participants considered in the meta-analyses, in total 71,613, ranged from 127 to 60,213 participants (eTable 9).

The study characteristics of the 104 included pandemic studies (early phase) are presented in Table 1. Although we imposed no restrictions on the age limits, we identified no studies conducted in children but did find some studies in the general population that included participants below the age of 18 years [47, 58].
Thus, the mean age of participants in the pandemic studies ranged from 20 (SD not reported) to 56.9 (SD 7.6) years [49, 99]1. The studies covered Asia (67 studies [26, 41–43, 49, 50, 54, 57, 58, 60, 62, 64, 71, 74, 76, 80, 81, 85, 86, 88–91, 93, 98, 101, 102, 104, 109, 111–116, 118–123, 126, 124, 128, 131–133, 136, 137, 140, 141, 143, 145]1 [18, 48, 59, 73, 84, 87, 92, 100, 105, 106, 108, 117, 134, 138, 139, 142, 144]1,2 [127]1,3 thereof from China [42, 49, 50, 57, 58, 60, 62, 64, 71, 80, 81, 85, 86, 88–91, 93, 101, 104, 109, 115, 116, 118–120, 122–124, 126, 128, 131–133, 136, 140, 141, 143, 145]1 [18, 48, 59, 84, 87, 92, 100, 105, 106, 108, 117, 134, 138, 139, 142, 144]1,2 [127]1,3, Europe (24 studies) [47, 99, 44, 93, 99, 44, 103, 135, 101, 102, 104, 105, 106, 108, 117, 134, 138, 142, 144]1,2, [127]1,3 and North America (six studies) [56, 67, 79, 81, 126, 128, 131–133, 136, 140, 141, 143, 145]1 [134, 138, 139, 144]1,2. The same was found for patients (Table 3); however, prepandemic data in patients were only available for four samples. Forest plots are presented in Figs. 2, 3, and eResults 2 in the Additional file 2.

In pairwise meta-analyses comparing pandemic (early phase) with prepandemic data for the four primary outcomes, however, we found only evidence for a small increase of anxiety (standardized mean difference [SMD] 0.40; 95% CI 0.15–0.65; \( p = .002 \)) and a moderate increase of depressive symptoms (SMD 0.67; 95% CI 0.07–1.27; \( p = .03 \)) in the general population. No evidence for a change in stress or sleep-related symptoms was identified (Table 3). For healthcare workers compared with healthcare staff before the pandemic, the meta-analyses showed no evidence of any effect on the primary outcomes (Table 3). The same was found for patients (Table 3); however, prepandemic data in patients were only available for four samples. Forest plots are presented in Figs. 2, 3, and eResults 1 in the Additional file 2.

Of the 104 studies, 38 studies were judged to be of fair quality and 57 studies of poor quality, with main concerns regarding selection bias, the validity of outcome measures, and the description of the sample and the survey period (eTable 12). From nine high-quality studies, four were representative surveys [44, 47, 77, 88]1. From the 85 pairwise comparisons relevant for meta-analyses, 52 comparisons were of level-1 and 33 of level-2 quality (eTable 13). When excluding low-quality pandemic studies (Table 3), the effects on anxiety and depressive symptoms in the general population increased. The effect on anxiety in the general population was stable in the sensitivity analysis when only best comparable data sets (ie, level-1 and level-2 comparability) were included, while there was no longer evidence for an effect on depressive symptoms (Table 3 and eResults 2 in Additional file 2).

Heterogeneity was considerable in main and sensitivity analyses, with \( I^2 \) scores mostly ranging from 90 to 100% and wide prediction intervals (Table 3). We therefore performed subgroup analyses with at least \( k = 5 \) studies in the main analyses in attempts to explain this heterogeneity (Table 4; eResults 3 in Additional file 2).

Regarding population characteristics (pandemic studies), age was no consistent risk or protective factor. Within the general population, we identified no evidence for a subgroup difference according to stressor exposure except for elevated sleep symptoms in isolated individuals [62]1. In healthcare workers, there was no evidence for a moderating effect of COVID-19 patient contact on mental health. In different groups of patients, we identified no evidence of differences in anxiety or depression. Compared with COVID-19 patients [131]1, psychiatric patients reported more stress, with the caveat of few studies [42, 132, 135]1.

Among general characteristics of the pandemic studies, we found no (consistent) evidence of differences depending on when the surveys started, whether they were conducted in China, or the sample size. We found evidence of an elevated level of depressive symptoms in the general population and patients depending on the specific outcome measure employed (eg, Patient Health Questionnaire [PHQ], Zung Self-Rating Depression Scale [SDS]).

In subgroup analyses for comparative study characteristics, there was no evidence of a consistent moderation of comparison sample sizes.

Across the three populations, we identified a higher level of anxiety and depressive symptoms if included studies were compared to prepandemic data published five or more years before versus a smaller burden in comparison to prepandemic data of less than 2 years ago.

The relationship of sample sizes explained the heterogeneity of the psychological impact of the SARS-CoV-2 pandemic in the general population and patients, with evidence for elevated symptoms of anxiety if similar sample sizes were compared.
| Study | Study design | Country | Sample size; female: No. (%) | Country (mode) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|-------|-------------|---------|-------------------------------|----------------|-----------|--------------|--------------------|----------------------|
| Ahmad et al. (2020) [43]\(^1\) | CS, OBS | Iraq (Kurdistan) | 516; 222 (43%); NA (mode: 18–35 years [65.1%]) | NA | NA | NA | Anxiety and fear | Binary single item\(^2\) |
| Bacon et al. (2020) [44]\(^1\) | CS, OBS | United Kingdom | 202; 127 (62.9%), 1 diverse; 33.79 (12.48) | NA | NA | March 18–19, 2020 | Anxiety and fear | GAD-7 |
| Bäuerle et al. (2020) [45]\(^1\), Teufel et al. (2020) [46]\(^1\) | CS, OBS | Germany | 15,037; 10,633 (70.7%), NA (mode: 25–34 years [24.8%]) | NA | NA | March 10–May 5, 2020 | Anxiety and fear | GAD-7, single item 7-P LS\(^a\), Depressive symptoms | STAI-Y, PSS |
| Buzzi et al. (2020) [47]\(^1\) | CS, OBS | Italy | 2064; NA; NA | NA | 100% adolescents | March 2020 | Anxiety and fear | 4-P LS\(^a\) |
| Cao et al. (2020) [48]\(^1\) | CS, OBS | China | 7143; 4975 (69.7%); NA | NA | NA | NA | Anxiety and fear | GAD-7 |
| Chang et al. (2020) [49]\(^1\) | CS, OBS | China | 3881; 2447 (63.1%); 20.00 (NA); P_{25} = 19.00, P_{75} = 22.00 | 100% students; medical students (n = 3359) | January 31, 2019–February 3, 2020 | Anxiety and fear | GAD-7 | PHQ-9 |
| Gao J et al. (2020) [50]\(^1\) | CS, OBS | China | 4872; 3267 (67.7%); 32.3 (10.0) | NA | NA | January 31–February 02, 2020 | Anxiety and fear | GAD-7 | WHO-5\(^c\) |
| Germani et al. (2020) [51]\(^1\) | CS, OBS | Italy | 1011; 720 (71.2%); 24.2 (3.6) | 100% age between 18 and 29 years | March 17–24, 2020 | Anxiety and fear | STAI-Y |
| González-Sanguino et al. (2020) [52]\(^1\) | CS, OBS | Spain | 3480; 2610 (75%); 37–92 (NA) | NA | NA | March 21–28, 2020 | Anxiety and fear | GAD-2 | PHQ-2, PCL-C-2 |
| Harper et al. (2020) [53]\(^1\) | CS, OBS | UK | 324; 162 (50%); 34–32 (11.71) | NA | NA | March 27–28, 2020 | Anxiety and fear | FCV-195, PROMIS-SF Anxiety, Promis-SF Depression |
| Jahanshahi et al. (2020) [54]\(^1\) | CS, OBS | Iran | 1058; 569 (53–8%); NA (mode: 26–35 years) | NA | NA | March 25–28, 2020 | Anxiety and fear | CPDI |
| Lauri Korajlija et al. (2020) [55]\(^1\) | CS (repeated), OBS | Croatia | sample 1: 888; 738\(^d\) (83–1%); 31.3 (10.45) sample 2: 966; 732\(^d\) (75.8%); 40 (11.94) | NA | NA | 1st period: February 24–NA 2nd period: March 19– | Anxiety and fear | 11-items 5-P LS based on Swine Flu Anxiety Items, Wheaton et al. |

\(^1\) CS = cross-sectional study, OBS = observation study

\(^a\) 7-P LS = 7-Item Life Stress Scale

\(^b\) P_{25}, P_{75} = 25th and 75th percentiles

\(^c\) WHO-5 = World Health Organization Well-Being Index

\(^d\) 5-P LS = 5-Item Life Stress Scale

\(^e\) Binary single item = binary single item for each outcome

\(^f\) Other outcomes include psychological distress, other outcomes, PROMIS-SF Anxiety, and PROMIS-SF Depression.
| Study | Study design | Country | Sample size; female: No. (%); age: mean (SD) or alternative information on age (eg, mode) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|-------|--------------|---------|---------------------------------------------------------------------------------|-----------|---------------|-------------------|---------------------|
| Lee SA et al. (2020) [56] | CS, OBS | USA | 398; 191 (49%); 35.91 (11.73) | NA | March 23–24, 2020 | Anxiety and fear | 2 single items P-P LS |
| Lei et al. (2020) [57] | CS, OBS | China | 1593; 976 (61.3%); 32.3 (9.8) | ‘affected group’: quarantined / relatives quarantined (n = 420) | February 04–10, 2020 | Anxiety and fear, Depressive symptoms | SAS, SDS |
| Li Y et al. (2020) [58] | CS (part of longitudinal cohort study), OBS | China | 1442; 891 (61.8%); NA (K-6 < 5: 20.0 [1.5]; K-6 ≥ 5: 20.0 [1.6]) | medical students (n = 764), nursing students (n = 211), medical technology students (n = 467) | February 7–13, 2020 | PTSS, Psychological distress | IES-R, K-6 |
| Liu N et al. (2020) [59] | CS, OBS | China | 285; 155 (54.4%); NA (47.7% < 35) | NA | January 30–February 08, 2020 | Anxiety and fear, Other outcomes | PTSS, PCL-5 |
| Liu S et al. (2020) [60] | CS, OBS | China | primary school: 209; 116 (56%); NA college: 198; 130 (62%); NA | primary school students, college students | February–March, 2020 | Anxiety and fear, Other outcomes | 3 items, 4-P LS |
| Lopez et al. (2020) [61] | CS, OBS | Spain | 878; 544d (62%) or 636 (72%) | 100% community-dwelling older adults; age 60–70 years (71%) | NA | Anxiety and fear, Other outcomes | BRCS, Ryff's PWB (subscales for personal growth and purpose in life) |
| Ma et al. (2020) [62] | CS, OBS | China | 123; 71d (57.7%); 37.4 (10.6) | 100% isolated people | January 2020 | Anxiety and fear, Depressive symptoms, Stress, Sleep-related symptoms, Other outcomes | DASS-21, DASS-21, DASS-21, DASS-21, SF-36 |
| Mazza et al. (2020) [63] | CS, OBS | Italy | 2766; 1982 (71.7%); 32.94 (13.2) | NA | March 18–22, 2020 | Anxiety and fear, Depressive symptoms, Stress, Sleep-related symptoms, Other outcomes | DASS-21, DASS-21, DASS-21, DASS-21, DASS-21 |
| McKay et al. (2020) [64] | CS, OBS | China | 908; 752 (82.8%); 40.37 (9.27) | NA | February 24–March 15, 2020 | Anxiety and fear, Depressive symptoms, Stress, Other outcomes | Co/GVAD-7, DASS-21, DASS-21, DASS-21 |
| Moccia et al. (2020) [65] | CS, OBS | Italy | 500; 298 (59.6%); NA (mode: 28–37 years, n = 129) | NA | April 10–13, 2020 | Psychological distress, Other outcomes | TEMPS-A |
Table 1  Study characteristics of included main studies (Continued)

| Study design | Country | Sample size; female: No. (%) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|--------------|---------|------------------------------|-----------|--------------|-------------------|----------------------|
| CS, OBS Spain | 2530; 1672 (66.1%); 27.9 (12.4) students (n = 1944); administrative staff (n = 247); faculty members and academic staff (n = 339)| Anxiety and fear, Depressive symptoms, Stress, PTSS, IES | March 28–April 3, 2020 | DASS-21 Anxiety, DASS-21 Depression, DASS-21 Stress, IES |
| CS, OBS USA | 501; 277 (55.29%); 32.44 (11.94) | NA | March 25, 2020–NA | Depressive symptoms | PHQ-2 |
| CS, OBS Spain | 976; 792 (81.1%); NA (mode: 18–25 years [56.5%]) | NA | March 11–15, 2020 | Anxiety and fear, Depressive symptoms, Stress | DASS-21 Anxiety, DASS-21 Depression, DASS-21 Stress |
| CS, OBS Turkey | 343; 169 (49.2%); 37.2 (10.3) | NA | April 14–16, 2020 | Anxiety and fear | HAI |
| CS, OBS Spain | 1014; 681 (67.2%); 40.87 (12.42) | NA | March 18–23, 2020 | Depressive symptoms | BIP-QS |
| CS, OBS China, Hong Kong, Macao, Taiwan | 52,730; 34,131 (64.7%) | NA | January 31–February 2, 2020 | Psychological distress | CPDIX|
| CS, OBS China | 1172; NA; NA | NA | February 14–March 29, 2020 | Anxiety and fear, Depressive symptoms, Stress, Sleep-related symptoms, PTSS, Other outcomes | GAD-7, PHQ-9, PSS-10, ISI, PCL-5, MINI suicidality module |
| CS, OBS Russia & Belarus | 850; 622 (73.2%); 34.8 (13.0) | NA | after March 27, 2020 | Anxiety and fear | FCV-19S |
| CS, OBS India | 662; 339 (51.2%); 29.09 (8.83) | NA | March 22–24, 2020 | Anxiety and fear | 18 items S-P LS^a |
| CS, OBS Bangladesh | 8550; 3760 (44%); 26.5 (9.1) | NA | April 1–10, 2020 | Anxiety and fear | FCV-19S |
| CS, OBS Turkey | 1304; 917 (70.3%); 29.5 (10.5) | NA | NA | Anxiety and fear | PHQ-9 |
| CS, OBS Bangladesh | 1066; 405 (38.5%); 27.80 | NA | March 28– | Psychological | COVID-19 |
| Study                        | Study design | Country     | Sample size; female: No. (%); age: mean (SD) or alternative information on age (eg, mode) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales          |
|-----------------------------|--------------|-------------|-------------------------------------------------------------------------------------------------|-----------|---------------|--------------------|--------------------------------|
| (2020) [76]                 |              |             | (10.05)                                                                                          |           |               |                    |                                 |
| Shevlin et al. (2020) [77]  | CS, OBS      | UK          | 2025; 1047 (51.9%); 45.4 (15.9)                                                                 | NA        | March 23–28, 2020 | Anxiety and fear  | GAD-7, VAS on COVID-19 anxiety |
| Soraci et al. (2020) [78]   | CS, OBS      | Italy       | 249; 229 (92%); 34.50 (12.21)                                                                      | NA        | March 18–21, 2020 | Anxiety and fear  | FCV-19S, HADS                |
| Sutin et al. (2020) [147]   | CS, OBS      | USA         | 2094; 1024 (48.9%); 51.03 (16.58)                                                                  | NA        | mid-March, 2020  | Anxiety and fear  | DASS-21 Anxiety, DASS-21 Depression, DASS-21 Stress, ISI |
| Tan W et al. (2020) [80]    | CS, OBS      | China       | 673; 172 (25.6%); 30.8 (7.4)                                                                       | NA        | February 24–252,020 | Anxiety and fear  | FCV-19S, GAD-7                |
| Tian et al. (2020) [81]     | CS, OBS      | China       | 1060; 511 (48.2%); 35.01 (12.8)                                                                    | HCW (n = 42), students (n = 330) | January 31–February 02, 2020 | Anxiety and fear  | SCL-90 Anxiety, SCL-90 Depression, SCL-90 GSI |
| Tsipropoulou et al. (2020)  | CS, OBS      | Greece      | 2970; 2153 (72.5%); NA (mode: 18–30 years [52%])                                                  | NA        | NA            | Anxiety and fear  | FCV-19S, GAD-7, PHQ-9 |
| Tull et al. (2020) [79]     | CS, OBS      | USA         | 500; 235 (47%); 40 (11.6)                                                                          | NA        | March 27–April 5, 2020 | Anxiety and fear  | DASS-21 Anxiety, SHAI DASS-21 Depression, DASS-21 Stress |
| Voitsidis et al. (2020)     | CS, OBS      | Greece      | 2363; 1800 (76.2%); NA (mode: 18–30 years [55%])                                                 | NA        | April 10–13, 2020 | Anxiety and fear  | PHQ-2, AIC IUS-12, JGLS |
| Wang C et al. (2020a) [84]   | 2 CS (repeated), OBS | China       | 1738 not counting participants in both surveys; 333 in both 1st survey: 1210; 814 (67.3%); NA (mode: 21.4–30.8 years [53.1%]) | NA        | January 31–February 2, 2020 and February 28–March 1, 2020 | Anxiety and fear  | DASS-21 Anxiety, DASS-21 Depression, DASS-21 Stress |
| (2020b) [85]                |              |             | 2nd survey: 861; 646 (75%);                                                                        |           |               |                    |                                 |
| Study                  | Study design | Country       | Sample size; female: No. (%) | age: mean (SD) or alternative information on age (eg, mode) | Subgroups | Survey period                  | Assessed Outcomes          | Instruments or scales |
|-----------------------|--------------|---------------|-----------------------------|--------------------------------------------------------------|------------|--------------------------------|---------------------------|----------------------|
| Wang H et al. (2020)  | CS, OBS      | China         | NA (mode: 21.4–30.8 years [46.5%]) | NA                                                           | NA         | February 1–4, 2020               | Psychological distress    | K-6                  |
| Wang Y et al. (2020)  | CS, OBS      | China         | 1599; 1068 (66.8%); 33.9 (12.3) | NA                                                           | NA         | February 6–9, 2020               | Anxiety                   | SAS                  |
| Yang H et al. (2020)  | CS (repeated), OBS | China         | during COVID-19: 3000; 1500\(^{A}\) (50%); 34.7 (NA) | NA                                                           | NA         | end of December 2019 and mid-February, 2020 | Other outcomes            | Emotional well-being (Kahneman and Deaton, 2010) |
| Yuan R et al. (2020)  | CS, OBS      | China         | parents of children hospitalised during the epidemic (EH): 50; 31 (62%\(^{A}\)); 36.80 (5.20) | EH (n = 50\(^{B}\)); NEH (n = 50\(^{B}\)) | NA         | NA                             | Anxiety                   | HADS Anxiety, VDAS, HADS Depression, SF-36 |
| Zhang SX et al. (2020) | CS, OBS      | China         | 369; 165 (44.7%); 36.6 (10.5) | NA                                                           | NA         | February 20–21, 2020              | Psychological Distress    | K6                   |
| Zhang Y et al. (2020) | CS, OBS      | China         | 263; 157 (60%); 37.7 (14.0) | NA                                                           | NA         | January 28–February 05, 2020      | PTSS                      | IES                  |
| Zhou SJ et al. (2020) | CS, OBS      | China         | 8079; 4326 (53.5%); NA (median: 16, minimum 12, maximum 18 years) | 100% senior high school students\(^{B}\) | NA         | March 8–15, 2020                  | Anxiety                   | GAD-7, PHQ-9          |
| Healthcare workers   |              |               |                             |                                                              |            |                                |                           |                      |
| Abdessater et al. (2020) | CS, OBS      | France        | 275; 91\(^{A}\) (33%) or 83\(^{A}\) (30%); ambigious data; 29.5 (0.47) | 100% urologists                                       | March 27–30, 2020 | Stress                     | a                         |                      |
| Ahmed et al. (2020)   | CS, OBS      | multinational (Pakistan > Saudi Arabia > others) | 650; 490 (75%); NA (mode: 20–30 years [54%]) | 100% dentists                                       | March 10–17, 2020 | Anxiety                   | 8 binary items\(^{a}\) |                      |
| Alhaj et al. (2020)   | CS, OBS      | multinational (Canada, USA, others) | 52; 14 (27%); NA (mode: < 30 years [69%]) | 100% surgeons                                       | April 14–28, 2020 | Psychological distress | Affection of mental health (binary single item) |                      |
| Amerio et al. (2020)  | CS, OBS      | Italy         | 131; 63 (48.1%); 52.3 (12.2) | 100% physicians (general practitioners) | March 15–April 15, 2020 | Anxiety                   | GAD-7, PHQ-9              |                      |
| Badahdah et al. (2020) | CS, OBS      | Oman          | 194; 116\(^{A}\) (60%); 40.72 (8.53) | 100% physicians                                       | early April 2020 | Anxiety                   | Stress                   | GAD-7, PSS-10, WHO-5\(^{c}\) |
Table 1 Study characteristics of included main studies (Continued)

| Study                  | Study design | Country                  | Sample size; female: No. (%) | Subgroups                                                                 | Survey period                | Assessed Outcomes                             | Instruments or scales |
|------------------------|--------------|--------------------------|-----------------------------|---------------------------------------------------------------------------|-----------------------------|-----------------------------------------------|----------------------|
| Bohlken et al. (2020)  | CS, OBS      | Germany                  | 396; NA; 165 (42%); 56.9 (7.6) | 100% physicians                                                          | April 1-6, 2020             | Anxiety and fear                              | Single items 5-P LS³ |
|                        |              |                          |                             |                                                                           |                             | Sleep disorders                               | Single item 5-P LS³  |
| Cai H et al. (2020)    | CS, OBS      | China                    | 534; 367 (69%); 36.4 (16.18) | physicians (n = 233), nurses (n = 248)                                   | January-March, 2020         | Anxiety and fear                              | Single items 4-P LS³ |
|                        |              |                          |                             |                                                                           |                             | Anxiety and fear                              | SCL-90 anxiety       |
| Cai W et al. (2020)    | CS, OBS      | China                    | whole sample: 1521; 1149 (75.5%); NA (mode: 18–30 years, [43.5%]) | physicians (n = 511), nurses (n = 546)                                   | NA                          | Anxiety and fear                              | SCL-90 depression    |
|                        |              |                          |                             |                                                                           |                             | Depressive symptoms                           | SCL-90 positive items |
|                        |              |                          |                             |                                                                           |                             | Psychological distress                        | SCL-90 subscales     |
|                        |              |                          |                             |                                                                           |                             | Other outcomes                                | CD-RISC, SRRS       |
| Chew et al. (2020)     | CS, OBS      | multinational (Singapore, India) | 906; 583 (64.3%); NA (median IQR: 29 [25–35] years) | physicians (n = 268), nurses (n = 355), allied healthcare professionals (n = 96), non-HCW (n = 187) | February 19–April 17, 2020 | Anxiety and fear                              | DASS-21 anxiety      |
|                        |              |                          |                             |                                                                           |                             | Depressive symptoms                           | DASS-21 depression   |
|                        |              |                          |                             |                                                                           |                             | Stress                                        | DASS-21 stress       |
|                        |              |                          |                             |                                                                           |                             | Sleep-related symptoms                        | Single item 4-P LS³  |
|                        |              |                          |                             |                                                                           |                             | Other outcomes                                | IES-R               |
| Consolo et al. (2020)  | CS, OBS      | Italy                    | 356; 141 (39.6%); NA (mode: 35–55 years [48.6%]) | 100% dentists                                                            | April 2–21, 2020            | Anxiety and fear                              | GAD-7               |
| Gan et al. (2020)      | CS, OBS      | China                    | 11,183; 10,811 (96.7%); NA (mode: 20–29 years) | 100% nurses                                                              | February 4–10, 2020         | Anxiety and fear                              | VAS on anxiety       |
| Huang JZ et al. (2020) | CS, OBS      | China                    | 230; 187 (81.3%); NA (mode: 30–39 years [53%]) | physicians (n = 70), nurses (n = 160)                                    | February 7–14, 2014         | Anxiety and fear                              | SAS                 |
|                        |              |                          |                             |                                                                           |                             | Stress                                        | VAS on stress        |
|                       |              |                          |                             |                                                                           |                             | Anxiety and fear                              | PTSS                |
|                       |              |                          |                             |                                                                           |                             | PTSS                                          | PTSD-5S             |
| Kang et al. (2020)     | CS, OBS      | China                    | 994; 850 (85.5%); NA (mode: 30–40 years [63.4%]) | physicians (n = 183), nurses (n = 811)                                    | January 20–February 4, 2020 | Anxiety and fear                              | PHQ-9               |
|                        |              |                          |                             |                                                                           |                             | Depressive symptoms                           | ISI                 |
|                        |              |                          |                             |                                                                           |                             | Sleep-related symptoms                        | ISI                 |
|                        |              |                          |                             |                                                                           |                             | Other outcomes                                | IES-R               |
|                        |              |                          |                             |                                                                           |                             | Defferential symptoms                         | CD-RISC, SRRS       |
| Khusid et al. (2020)   | CS, OBS      | USA                      | 332; 117 (35%); 30.5 (2.6)  | 100% urologists                                                           | April 7–11, 2020            | Anxiety and fear                              | GAD-7               |
|                        |              |                          |                             |                                                                           |                             | Sleep-related symptoms                        | 2 items 5-P LS³     |
| Lai et al. (2020)      | CS, OBS      | China                    | 1257; 964 (76.7%); NA (mode: 26–40 years [64.7%]) | physicians (n = 493), nurses (n = 764)                                    | January 29–February 3, 2020 | Anxiety and fear                              | PHQ-9               |
|                        |              |                          |                             |                                                                           |                             | Depressive symptoms                           | ISI                 |
|                       |              |                          |                             |                                                                           |                             | Sleep-related symptoms                        | IES                 |
Table 1 Study characteristics of included main studies (Continued)

| Study                  | Study design | Country         | Sample size; female: No. (%) | age: mean (SD) or alternative information on age (eg, mode) | Subgroups                                      | Survey period                  | Assessed Outcomes                | Instruments or scales |
|------------------------|--------------|-----------------|-------------------------------|-----------------------------------------------------------|-----------------------------------------------|---------------------------------|-------------------------------|----------------------|
| Mo et al. (2020) [108] | CS, OBS      | China           | 180; 162 (90%); 32.71 (6.52)  | NA                                                       | end of February 2020                          | Anxiety and fear                | SAS                           |                      |
| Pu et al. (2020) [109] | CS, OBS      | China           | 867: 829 (95.6%); 30.8 (7.1)  | 100% nurses                                              | NA                                            | Anxiety and fear                | SAS                           | TAF                  |
| Rossi et al. (2020) [110] | CS, OBS     | Italy           | 1379; 1064 (77.2%); 39.0 (6.0) | physicians (n = 433), general practitioners (n = 86), nurses (n = 472) | March 27–31, 2020                            | Anxiety and fear                | GAD-7, PHQ-9, PSS, ISI, GPS–PTSD |                      |
| Sahu et al. (2020) [111] | CS, OBS      | India           | 611; NA; NA (mode: 30–40 years, n = 192 [31.4%]) | 100% orthopedic surgeons                               | March 31–April 4, 2020                      | Psychological distress          | K-6                            | Single-item^a          |
| Shacham et al. (2020) [112] | CS, OBS   | Israel          | 338; 198 (58.6%); 46.39 (11.2) | dentists (n = 198), dental hygienists (n = 140^a)       | March 30–April 10, 2020                     | Anxiety and fear                | SCL-90 anxiety, SCL-90 depression, SDS |                      |
| Suleiman et al. (2020) [113] | CS, OBS     | Jordan          | 308; 113 (36.7%); 30.3 (5.8)  | 100% physicians                                         | March 23–27, 2020                           | Anxiety and fear                | SCL-90 total score, SCL-90 subscales |                      |
| Tan B et al. (2020) [114] | CS, OBS      | Singapore       | 470; 321 (68.3%); NA (median: 31, IQR: 28–36 years) | physicians (n = 135), nurses (n = 161), allied hospital personnel (n = 174) | February 19–March 13, 2020                  | Anxiety and fear                | DASS-21 anxiety, DASS-21 depression, IES-R |                      |
| Wang S et al. (2020) [115] | CS, OBS      | China           | 123; 111 (90%); 33.75 (8.41)  | 100% pediatricians; physicians (n = 48), nurses (n = 75) | January 30–February 07, 2020                | Anxiety and fear                | SAS                           |                      |
| Wu K et al. (2020) [116] | CS, OBS,     | China           | experimental group: 60; 44 (73%); 33.5 (12.4) comparison group: 60; 45 (75%); 33.8 (11.9) | COVID-19 hospital (n = 60), non-designated hospital = comparison group (n = 60) | NA                                           | Anxiety and fear                | SAS, SCL-90 anxiety, SCL-90 depression, SDS |                      |
| Xiao et al. (2020a) [117] | CS, OBS      | China           | 180; 129 (71.7%); 32.31 (4.88) | physicians (n = 82), nurses (n = 98)                    | January–February, 2020                      | Anxiety and fear                | SAS                           | PSQI                 |
| Study | Study design | Country | Sample size; female: No. (%) | Age: mean (SD) or alternative information on age (eg, mode) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|-------|-------------|---------|-----------------------------|-------------------------------------------------|-----------|----------------|-----------------|---------------------|
| Xu J et al. (2020) [118] | CS, OBS, controlled | China | outbreak period: 60; 38 (63.3%); 36.68 (9.67) ‘post-epidemic’: 60; 32 (53.3%); 35.77 (7.06) | 100% surgeons | January 28–February 29, 2020 and March 2–21, 2020 | Anxiety and fear | GSES, SASR, SSRS |
| Yin et al. (2020) [119] | CS, OBS | China | 371; 228 (61.5%); 35.3 (9.5) physicians: NA nurses: NA | 34 (9.5%) | February 01–05, 2020 | Sleep-related symptoms | PSQI |
| Zhang C et al. (2020) [120] | CS, OBS | China | 1563; 1293 (83%); NA (mode: 26–40 years, \( n = 495 \) [31.7%]) physicians: NA nurses: NA | 67, 264 (50.4%) | January 29–February 03, 2020 | Anxiety and fear | GAD-7, PHQ-9 |
| Zhang SX et al. (2020c) [121] | CS, OBS | Iran | 304; 178 (58.6%); 35.1 (9.1) | NA | April 5–20, 2020 | Anxiety and fear | GAD-2d, PHQ-2d, K6 |
| Zhu J et al. (2020) [122] | CS, OBS | China | 156; 137 (83%); 34.16 (8.06) physicians: 79; 51 (65%) nurses: NA | 100% cured COVID-19 patients | February 1–29, 2020 | Anxiety and fear | SAS |
| Patients | | | | | | | | |
| Cai X et al. (2020) [123]; Yuan B et al. (2020) [124] | CS, OBS | China | 126; 66 (52.4%); 45.7 (14.0) | 100% cured COVID-19 patients | March 2–12, 2020 | Anxiety and fear | SAS |
| Durankus et al. (2020) [125] | CS, OBS | Turkey | 260; 260 (100%); 29.6 (3.8) | 100 pregnant women | NA | Anxiety and fear | BAI |
| Li X et al. (2020) [126] | CS, OBS | China | 76; 35 (46%); 36 (15) | suspected COVID-19 patients | January 31–February 22, 2020 | Anxiety and fear | HAMA |
| Liu X et al. (2020a) [42] | CS, OBS | China | COVID-19 suspected patients: 21; 12 (57.1%); 43.1 (2.6); not COVID-19 suspected | 100% schizophrenia patients; COVID-19 suspected patients | January 30–February 21, 2020 | Anxiety and fear | HAMA |
Table 1 Study characteristics of included main studies (Continued)

| Study | Study design | Country | Sample size; female: No. (%) or alternative information on age (eg, mode) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|-------|--------------|---------|---------------------------------------------------------------------------|-----------|---------------|-------------------|----------------------|
| Wu Y et al. (2020) [127] | CS, OBS | China | 4124; 4124 (100%6), NA (median: 30, range = 17–32 years) | 100% pregnant women; before (group 1: n = 2839) after (group 2: n = 1284) January 20, 2020 | January 1–February 9, 2020 | Depressive symptoms | HAMD |
| | | | | | | | PSS | Sleep-related symptoms |
| | | | | | | PSQI | Other outcomes |
| | | | | | | PANSS | |
| Xu H et al. (2020) [128] | CS, OBS | China | 350; 199 (54.1%); NA (mode: 40–60 years [51%]) | 100% lung cancer patients | March 4–6, 2020 | Depressive symptoms | EPDS-3A |
| | | | | | | Sleep-related symptoms | Single itema |
| | | | | | | Other outcomes | Single itema |
| Yassa et al. (2020) [129] | CS, OBS | Turkey | 172; 172 (100%); 27.5 (5.3) | 100% pregnant women ten days after first confirmed COVID-19 death in Turkey | | Psychological distress | K-6 |
| Büntzel et al. (2020) [130] | CS, OBS | Germany | 193; NA; NA (mode: > 60 years) | physicians (n = 47), cancer patients (n = 146) | April 16–19, 2020 | Anxiety and fear | Single itema |
| | | | | | | Stress | Single itema |
| Guo et al. (2020) [131] | CS, OBS, controlled | China | P: 103; 44 (42.7%); 42.5 (12.5); control (GP): 103; 49 (47.6%); 41.5 (13.1) | COVID-19 patients (n = 103), not infected control group (n = 103) | February 10–28, 2020 | Anxiety and fear | GAD-7 |
| | | | | | | Stress | PHQ-9 |
| | | | | | | Sleep-related symptoms | PSS-10 |
| | | | | | | Other outcomes | ISI |
| Hao F et al. (2020) [132] | CS, OBS, controlled | China | P: 76; 51 (37.1%); 32.8 (11.8); control (GP): 109; 68 (62.4%); 33.1 (11.2) | psychiatric patients (n = 76), control group (n = 109) | February 19–22, 2020 | Anxiety and fear | DASS-21 anxiety |
| | | | | | | Depressive symptoms | DASS-21 depression |
| | | | | | | Stress | DASS-21 stress |
| Hao X et al. (2020) [133] | CS, OBS, controlled | China | P: 252; 132 (52.4%); 29.3 (11.6); control (GP): 252; 132 (52.4%); 29.4 (11.5) | epilepsy patients (n = 252), control group (n = 252) | February 1–29, 2020 | Psychological distress | IES-R |
| Huang Y et al. (2020) [134] | CS, OBS | China | GP (n = 4986), HCW (n = 2250) | | February 3–17, 2020 | Anxiety and fear | GAD-7 |
| | | | | | | Depressive symptoms | CES-D |
| | | | | | | Sleep-related symptoms | PSQI |
| Iasevoli et al. | CS, OBS | Italy | 461; NA; NA | psychiatric patients | April 13–17, 2021 | Anxiety and fear | GAD-7 |
| Study | Design | Country | Sample size; female: No. (%) | Age: mean (SD) or alternative information on age (eg, mode) | Subgroups | Survey period | Assessed outcomes | Instruments or scales |
|-------|--------|---------|-----------------------------|------------------------------------------------------------|-----------|---------------|------------------|---------------------|
| (2020) [135] | controlled | P: 205; NA; NA caregivers: 51; NA; NA control (GP): 205; NA; NA | (n = 205), caregivers (n = 51), non-psychiatric persons (n = 205) | 2020 | fear | Depressive symptoms | PHQ-9 |
| Jin YH et al. (2020) [136] | CS, OBS | China | 103; 64 (62.1%); NA (median [IQR]: 35 [14.0]) | 100% infected with SARS-CoV-2; physicians, nurses | February 15–29, 2020 | Anxiety and fear | Single item multiple choice a |
| Ko et al. (2020) [137] | CS, OBS | Taiwan | 1904; 1282 (67.3%); 38.0 (10.8) | 100% infected with SARS-CoV-2; other outcomes | April 10–20, 2020 | Anxiety and fear | HAMA, NRS on fear |
| Li Z et al. (2020) [138] | CS, OBS | China | 740; 128 (59.8%); 25 (IQR: 22–38.3 years) | GP (n = 214), HCW (n = 526) | February 17–21, 2020 | Anxiety and fear | HAMD |
| Lu W et al. (2020) [139] | CS, OBS | China | 2299; 1785 (77.6%); NA (78% < 40 years) | HCW (n = 2042), GP (n = 257) | February 25–26, 2020 | Anxiety and fear | HAMA, NRS on fear |
| Ni et al. (2020) [140] | CS, OBS | China | total: 1791; NA; NA GP: 1577; 1218 (60.8%); NA (mode: 18–34 years 38.6%); HCW: 214; 147 (68.8%); NA (mode: 18–34 years 58.9%) | GP (n = 1577), HCW (n = 214) | February 18–24, 2020 | Anxiety and fear | GAD-2 |
| Sanchez et al. (2020) [67] | CS, OBS | USA | 1051; 0 (0%); 35 (15.83) | 100% men who have sex with men; HIV-patients (n = 122) | April 2–13, 2020 | Anxiety and fear | Single item a |
| Wu W et al. (2020) [141] | CS, OBS | China | 4268; 2930 (68.7%); NA HCW: 2110; 1598 (76%); NA Students: 2158; 1332 (62%); NA | students (n = 2158), HCW (n = 2110) | February 10–21, 2020 | Anxiety and fear | Single item a |
| Yuan S et al. (2020) [142] | L, OBS | China | 939; 582 (61.98%); NA (mode: 18–39 years 71.5%) | HCW (n = 249), students (n = 312) | February 2 survey periods in February, 2020 | Sleep-related symptoms | PSQI, SRQ |
| Zhang J et al. (2020) [143] | CS, OBS | China | 205; 115 (56.1%); NA (for infected: 46.9 [154]; for quarantined: 36.2 [109]; for general public: 29.6 [127]) | P, infected (n = 57), GP, quarantined (n = 50), GP, general public (n = 98) | February 15–29, 2020 | Anxiety and fear | GAD-7 |
| Zhang WR et al. (2020) [144] | CS, OBS | China | 2182; 1401 (64.2%); NA (mode: 18–60 years 96.3%) | HCW (n = 927), GP (n = 1255) | February 19–March 6, 2020 | Anxiety and fear | GAD-2 |
| Zhu S et al. (2020) [145] | CS, OBS | China | 2279; 1361 (6), NA | HCW (n = 858), GP (n = 1421) | Feb 12–Mar 17, 2020 | Anxiety and fear | PHQ-9 |
The risk and protective factors narratively identified for each population are presented in Table 5 and eTables 14 and 15, with most of them being investigated in the general population, and few studies investigating protective factors at all. Most frequently named risk factors across the populations were pre-existing mental disorders, female sex, and concerns about COVID-19 infection, whereas most frequently reported protective factors were older age, good economic situation, and higher education.

**Discussion**

To our knowledge, this is the first systematic review and meta-analysis to assess the mental health impact of the SARS-CoV-2 pandemic in the general population, but not of stress or sleeping problems.

Although healthcare workers were found to be a group at risk for mental health problems during the SARS-CoV-2 pandemic [18]^[20, 29, 31, 32], we identified no evidence for an increased mental burden during the early phase when comparing them with healthcare staff prior to the pandemic. Because of a (chronic) work-related risk exposure in daily life [194], as a kind of ‘stress inoculation’, healthcare professionals might have learned effective strategies (eg, self-efficacy) helping them to cope more professionally with crises than other groups. In contrast to previous findings [20, 195], the level of COVID-19 patient contact did not affect the mental health impact.

Overall, the results of this review paint a more nuanced picture of the mental health consequences of the SARS-CoV-2 pandemic than previous reviews – an observation in line with stress resilience research that identified different trajectories of psychological adaptation after potentially traumatic events, ranging from no mental burden to severe mental illness [196, 197]. Indeed, a recent analysis of 523 healthy subjects from the German LORA study showed a decrease of perceived stress and stressor load while mental health improved during the eight-week measurement after lockdown, indicating that the pandemic and pandemic response may also have

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**Table 1** Study characteristics of included main studies (Continued)

| Study design | Country | Sample size; female: No. (%) | Subgroups | Survey period | Assessed Outcomes | Instruments or scales |
|--------------|---------|-----------------------------|-----------|---------------|-------------------|---------------------|
|              |         |                             |           |               |                   |                     |

Abbreviations: AIS Athens Insomnia Scale, BAI Beck Anxiety Inventory, BDI Beck Depression Inventory, BDI-2 Beck Depression Inventory, BIP-OS Brief Illness Perception Questionnaire 5, BRCB Brief Resilience Coping Scale, CD-RISC Connor-Davidson Resilience Scale, CES-D Center for Epidemiologic Studies Depression Scale, CoVGAD-7 Generalized Anxiety Disorder Scale-7 for COVID-19 Anxiety, CPDI CoV-ID-19 Peritraumatic Distress Index, CS cross-sectional, DASS-21 Depression Anxiety Stress Scale-21, DT Distress Thermometer, EPDS Edinburgh Postnatal Depression Scale, EPDS-3A Edinburgh Postnatal Depression Scale Anxiety subscale, FACIT-Sp12 Functional Assessment of Chronic Illness Therapy-Spiritual Well-Being Scale, FCV-19S Fear of COVID-19 scale, GAD-2 Generalized Anxiety Disorder Scale-2, GP general population, GPS-PTSD Global Psychotrauma Scale-posttraumatic stress disorder subscale, GSES General Self-Efficacy Scale, GSI Global Severity Index, HADS Hospital Anxiety and Depression Scale, HAI Health Anxiety Inventory, HAMA Hamilton Anxiety Rating Scale, HAMD Hamilton Depression Rating Scale, HCW healthcare workers, IES Impact of Event Scale, IES-R Impact of Event Scale-Revised, IQR interquartile range, ISI Insomnia Severity Index, IUS-12 Intolerance of Uncertainty Scale-Short Form, JGLS De Jong Gierveld Loneliness Scale, K-6(−10) Kessler Psychological Distress Scale-6(−10), L longitudinal, MINI Mini International Neuropsychiatric Interview, MSPPS Multidimensional Scale of Perceived Social Support, NA not available, NRS Numerical Rating Scale, OBS observational, P patients, PANSS Positive and Negative Syndrome Scale, PCL-5(−C) Post-traumatic Stress Disorder Checklist-5(−Civilian Version), PHQ-2(−4/9−15) Patient Health Questionnaire-2(−4/9−15), PROMIS-5SF Patient Reported Outcomes Measurement Information System short forms, PSQI Pittsburgh Sleep Quality Index, PSS(−10) Perceived Stress Scale(−10), PTSD-SS Post-traumatic Stress Disorder Self-rating Scale, PTSS post-traumatic stress symptoms, Ryff’s PWB Ryff’s Psychological Wellbeing Scales, SASR Self-Rating Anxiety Scale, SASSR Stanford Acute Stress Reaction, SCL-90 Symptom Checklist-90, SCS Self-Compassion Scale, SD standard deviation, SDQ Strengths and Difficulties Questionnaire, SDS Self-Rating Depression Scale, SF-12(−36) Short Form 12 Health Survey, SHAI Short Health Anxiety Inventory, SSD Stress Overload Scale, SPEQ Specific Psychotic Experience Questionnaire, SRQ Stress Response Questionnaire, SRQ-20 20-item Self Report Questionnaire, SSRS Social Support Rating Scale, SSS Somatic Symptom Scale, STAY State Trait Anxiety Inventory-Y, SWLS Satisfaction With Life Scale, TAF Triage Assessment Form, TEMPS-A Temperament Evaluation of Memphis, Pisa, Paris and San Diego-Anxious, VAS Visual Analogue Scale, VDAS Van Dream Anxiety Scale, WHO-5 World Health Organization- Five Well-Being Index, WHOQOL-BREF abbreviated World Health Organization Quality of Life, 4−/5−/6−/11−point Likert-scale

a developed by study authors
b included in main analyses for general population but considered separately in subgroup-analyses
c in Gao J et al WHO-5 is used to assess depressive symptoms, in Badahah et al it is used to assess psychological distress
d not directly reported

e k-means-clustering method for the 4 tools summarized to ‘mental health’
positive effects [198]. The number of studies reporting on protective factors in this review was rather limited, especially in healthcare workers and patients. However, these factors might also partly explain the heterogeneity of findings regarding mental health consequences. This is in line with positive aspects (eg, improved social relationships with close social contacts such as families) that were likewise reported for previous infectious disease outbreaks. The importance of taking a ‘resilience perspective’ in SARS-CoV-2 mental health research and investigating resilience factors has been pointed out previously [19, 22, 197, 199].

Several aspects must be considered when interpreting the results. First, the absence of evidence of effects in healthcare workers and patients in this review does not necessarily mean that there is evidence for the absence of effects of the SARS-CoV-2 pandemic on mental health in these groups. Second, for healthcare workers, the mental burden on individuals probably depends on the location of survey (eg, country, region) and how heavily the respective healthcare systems were burdened in the pandemic timeline (eg, number of hospitalized COVID-19 patients). Among the 13 included studies in meta-analyses for healthcare staff, we could only include

### Table 2 Narrative synthesis of prevalence based on scores above cut-off values for different mental health outcomes

| General population | Number of studies | Lowest reported prevalence (%) | Highest reported prevalence (%) |
|--------------------|------------------|-------------------------------|-------------------------------|
| Anxiety, worries, fear | 24 [18 GP, 45, 47, 49, 50, 52, 57, 63, 66, 68, 69, 71, 77, 93] [73, 84, 87] | 0.67 (63) | 64.0 (46) |
| Depressive symptoms | 18 [13 GP, 45, 49, 50, 52, 57, 63, 66, 68, 69, 71, 93] [84, 87] | 0.9 (89) | 48.3 (48) |
| PTSS | 7 [6 GP, 52, 66, 71] [59, 84, 92] | 7.0 (51) | 53.8 (55) |
| Sleep-related symptoms | 6 [3 GP, 71, 83] [84] | 0.9 (89) | 37.6 (131) |
| Stress | 5 [4 GP, 66, 68, 71, 83] | 0.9 (89) | 67.9 (55) |
| Psychological distress | 7 [5 GP, 41, 45, 58, 81] | 1.6 (90) | 65.2 (112) |

| Healthcare workers | Number of studies | Lowest reported prevalence (%) | Highest reported prevalence (%) |
|--------------------|------------------|-------------------------------|-------------------------------|
| Anxiety, worries, fear | 22 [14 HCW, 99, 95, 113, 102, 103, 110, 115, 120, 122, 121] | 7.0 (108) | 92.0 (144) |
| Depressive symptoms | 14 [9 HCW, 97, 102, 110, 115, 120, 121, 122] [18, 106] | 0.6 (110) | 50.4 (18) |
| PTSS | 7 [HCW, 102, 110, 119, 120] [18, 105, 106] | 3.8 (82) | 73.0 (83) |
| Sleep-related symptoms | 9 [7 HCW, 99, 102, 110, 115, 120] [18, 106] | 8.27 (127) | 38.0 (108) |
| Stress | 6 [5 HCW, 94, 102, 110, 111] | 5.2 (102) | 56.5 (114) |
| Psychological distress | 5 [4 HCW, 96, 101, 112, 121] | 11.1 (101) | 90.4 (145) |

| Patients | Number of studies | Lowest reported prevalence (%) | Highest reported prevalence (%) |
|---------|------------------|-------------------------------|-------------------------------|
| Anxiety, worries, fear | 6 [5 P, 123, 126, 129, 131, 143] | 19.5 (99) | 80.2 (143) |
| Depressive symptoms | 8 [7 P, 123, 125, 126, 128, 131, 143] [127] | 27.8 (99) | 55.3 (88) |
| PTSS | 2 [1 P, 123] | 31.0 (84) | 43.4 (89) |
| Sleep-related symptoms | 2 [1 P, 128] | 27.6 (89) | 66.3 (97) |
| Stress | 1 [M] | 17.0 (89) |  |
| Psychological distress | 1 [M] | 13.1 (90) |  |

Abbreviations: GP general population, HCW healthcare workers, M mixed samples, P patients, PTSS posttraumatic stress symptoms

* reporting prevalence rates for the respective mental health outcome
| Outcome                  | Main analyses                                                                 | Sensitivity analysis – Quality of included pandemic studies (ie, exclusion of poor-quality studies) | Sensitivity analysis – Level of comparability between included pandemic studies and comparative studies (ie, exclusion of level-3 and level-4 studies) |
|-------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
|                         |                                                                                |                                                                                                  |                                                                                                                                     |
|                         | **Studies**                                                                   | **N (pandemic)** | **N (comp.)** | **Standardized mean difference (95% CI)** | **I²** | **95% prediction interval** |
| **Main analyses**       |                                                                                |                                                                                                  |                                                                                                                                     |
| **General population**  |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 23 (26)                         | 49,746                                               | 132,145                                               | 0.40 (0.15–0.65)                                              | 99%   | −0.87–1.67                   |
| Depression              | 25 (28)                         | 60,213                                               | 183,747                                               | 0.67 (0.07–1.27)                                              | 100%  | −2.02–3.36                   |
| Stress                  | 11 (13)                         | 11,600                                               | 67,386                                               | 0.10 (−0.30–0.50)                                             | 100%  | −1.39–1.60                   |
| Sleep-related symptoms  | 4 (4)                           | 3332                                                | 7635                                                | 0.74 (−1.47–2.96)                                             | 100%  | −3.68–5.17                   |
| **Healthcare workers**  |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 13 (14)                         | 5508                                                | 22,204                                               | −0.08 (−0.66–0.49)                                            | 99%   | −1.75–1.58                   |
| Depression              | 7 (8)                           | 2226                                                | 4605                                                | −0.16 (−0.59–0.26)                                            | 97%   | −1.41–1.09                   |
| Stress                  | 3 (3)                           | 1570                                                | 2454                                                | 0.49 (−0.60–1.57)                                             | 99%   | /                             |
| Sleep-related symptoms  | 4 (5)                           | 554                                                 | 20,024                                               | 0.83 (−0.14–1.81)                                             | 99%   | −1.54–3.21                   |
| **Patients**            |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 6 (6)                           | 1845                                                | 12,458                                               | 0.31 (−0.07, 0.69)                                            | 93%   | −1.08–1.69                   |
| Depression              | 7 (7)                           | 2138                                                | 24,444                                               | 0.48 (−0.08–1.04)                                             | 98%   | −1.58–2.53                   |
| Stress                  | 4 (4)                           | 435                                                 | 10,061                                               | −0.10 (−0.81–0.61)                                            | 98%   | −3.54–3.34                   |
| Sleep-related symptoms  | 2 (2)                           | 127                                                 | 298                                                 | −0.61 (−1.75–0.54)                                            | 96%   | /                             |
| **Sensitivity analysis – Quality of included pandemic studies (ie, exclusion of poor-quality studies)** |                                                                                |                                                                                                  |                                                                                                                                     |
| **General population**  |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 16 (17)                         | 38,323                                               | 81,350                                               | 0.53 (0.19–0.86)                                              | 100%  | −0.90–1.95                   |
| Depression              | 18 (19)                         | 48,790                                               | 136,884                                              | 0.83 (0.09–1.57)                                              | 100%  | −2.17–3.82                   |
| Stress                  | 7 (8)                           | 9110                                                | 43,747                                               | 0.33 (−0.19–0.84)                                             | 100%  | −1.20–1.85                   |
| Sleep-related symptoms  | 3 (3)                           | 2659                                                | 6622                                                | 0.80 (−1.34–2.94)                                             | 100%  | /                             |
| **Healthcare workers**  |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 4 (4)                           | 1655                                                | 4124                                                | −0.18 (−0.78–0.41)                                            | 97%   | −1.30–0.94                   |
| Depression              | 4 (4)                           | 1655                                                | 2356                                                | 0.03 (−0.42–0.47)                                             | 90%   | −0.73–0.79                   |
| Stress                  | 2 (2)                           | 1376                                                | 1872                                                | −0.05 (−0.37–0.26)                                            | 95%   | /                             |
| Sleep-related symptoms  | 1 (1)                           | 123                                                 | 4951                                                | −0.03 (−0.21–0.15)                                            | /     | /                             |
| **Patients**            |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 3 (3)                           | 1461                                                | 11,116                                               | 0.45 (−0.10–1.01)                                             | 92%   | /                             |
| Depression              | 3 (3)                           | 1461                                                | 21,934                                               | 0.21 (−1.08–1.49)                                             | 99%   | /                             |
| Stress                  | 1 (1)                           | 51                                                  | 51                                                  | 0.18 (−0.21–0.57)                                             | /     | /                             |
| Sleep-related symptoms  | 1 (1)                           | 51                                                  | 207                                                 | −0.03 (−0.33–0.28)                                            | /     | /                             |
| **Sensitivity analysis – Level of comparability between included pandemic studies and comparative studies (ie, exclusion of level-3 and level-4 studies)** |                                                                                |                                                                                                  |                                                                                                                                     |
| **General population**  |                                                                                |                                                                                                  |                                                                                                                                     |
| Anxiety                 | 12 (13)                         | 38,461                                               | 32,698                                               | 0.40 (0.06–0.74)                                              | 99%   | −0.77–1.57                   |
| Depression              | 14 (15)                         | 38,259                                               | 78,619                                               | 0.77 (−0.23–1.77)                                             | 100%  | −2.72–4.25                   |
| Stress                  | 7 (8)                           | 8624                                                | 12,739                                               | −0.15 (−0.76–0.46)                                            | 99%   | −1.84–1.53                   |
| Sleep-related symptoms  | 2 (2)                           | 2550                                                | 5609                                                 | 1.54 (−1.18–4.27)                                             | 100%  | /                             |

Table 3 Results of main and sensitivity analyses in three populations.
a few studies from heavily burdened countries (e.g., Italy: \( k = 2 \); Spain: \( k = 0 \); USA: \( k = 0 \)). However, nine studies in these meta-analyses had been conducted in China, which, compared internationally, was less affected by the SARS-CoV-2 pandemic [4]. In the subgroup analysis regarding the level of COVID-19 patient contact, we assigned studies to the subgroup ‘high level of contact’ if at least 50% of the sample had close contact to COVID-

### Table 3 Results of main and sensitivity analyses in three populations (Continued)

| Outcome                  | Studies (samples) | N (pandemic) | N (comp.) | Standardized mean difference (95% CI) | \( I^2 \) | 95% prediction intervala |
|--------------------------|-------------------|--------------|-----------|--------------------------------------|--------|--------------------------|
| **Healthcare workers**   |                   |              |           |                                       |        |                          |
| Anxiety                  | 7 (8)             | 3147         | 9511      | −0.54 (−1.23–0.15)                    | 99%    | −2.11–1.03               |
| Depression               | 4 (5)             | 546          | 2576      | −0.38 (−1.56–0.79)                    | 98%    | −2.60–1.84               |
| Stress                   | /                 | /            | /         | /                                    | /      | /                        |
| Sleep-related symptoms   | 3 (4)             | 423          | 19,804    | 1.01 (−0.17–2.18)                     | 99%    | −1.61–3.63               |
| **Patients**             |                   |              |           |                                       |        |                          |
| Anxiety                  | 4 (4)             | 1616         | 3184      | 0.23 (−0.03–0.79)                     | 92%    | −2.47–2.93               |
| Depression               | 4 (4)             | 1704         | 3205      | 0 (−0.56–0.56)                       | 93%    | −2.69–2.70               |
| Stress                   | 2 (2)             | 127          | 217       | 0.15 (−0.08–0.37)                    | 0%     | /                        |
| Sleep-related symptoms   | 2 (2)             | 127          | 298       | −0.61 (−1.75–0.54)                   | 96%    | /                        |

Abbreviations: CI confidence interval, comp. comparative studies, \( I^2 \) heterogeneity, \( N \) sample size, pandemic included pandemic studies

a 95% prediction interval only calculated for meta-analyses with at least \( k = 4 \) studies

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### Study Table

| Study                     | Total Mean | SD | Total Mean | SD | Std. Mean Difference | IV Random, 95% CI | Std. Mean Difference | IV Random, 95% CI |
|---------------------------|------------|----|------------|----|----------------------|-------------------|----------------------|-------------------|
| COVID-19                  | 15006      | 5.26 | 4.76      | 1011 | 14.60 | 12.7000 | 3881 | 3.033 | 3.1250 | 1092 | 15.00 | 2.7000 | 3480 | 1.79 | 1.6300 | 110 | 1.21 | 1.3900 | 0.36 | 0.17 | 0.3500 | 1590 | 36.47 | 9.1500 | 1156 | 20.78 | 4.6000 | 0.96 | 0.80 | 0.9400 | 2500 | 3.34 | 3.8700 | 1055 | 4.84 | 5.7500 | 0.33 | -0.41 | -0.20 |
| pre-COVID-19              | 50300      | 2.95 | 3.4700 | 2983 | 37.38 | 11.5100 | 1092 | 15.00 | 2.7000 | 3480 | 1.79 | 1.6300 | 110 | 1.21 | 1.3900 | 0.36 | 0.17 | 0.3500 | 1590 | 36.47 | 9.1500 | 1156 | 20.78 | 4.6000 | 0.96 | 0.80 | 0.9400 | 2500 | 3.34 | 3.8700 | 1055 | 4.84 | 5.7500 | 0.33 | -0.41 | -0.20 |
| Std. Mean Difference IV Random | 95% CI     | 0.50 | 0.47 | 0.54 | 0.95 | 0.87 | 1.02 | 0.36 | 0.17 | 0.35 | 0.96 | 0.80 | 0.94 | 0.33 | -0.41 | -0.20 |
| Std. Mean Difference IV Random | 95% CI     | -0.24 | 0.50 | 0.47 | 0.54 | 0.95 | 0.87 | 1.02 | 0.36 | 0.17 | 0.35 | 0.96 | 0.80 | 0.94 | 0.33 | -0.41 | -0.20 |
| Std. Mean Difference IV Random | 95% CI     | -0.24 | 0.50 | 0.47 | 0.54 | 0.95 | 0.87 | 1.02 | 0.36 | 0.17 | 0.35 | 0.96 | 0.80 | 0.94 | 0.33 | -0.41 | -0.20 |
| Std. Mean Difference IV Random | 95% CI     | -0.24 | 0.50 | 0.47 | 0.54 | 0.95 | 0.87 | 1.02 | 0.36 | 0.17 | 0.35 | 0.96 | 0.80 | 0.94 | 0.33 | -0.41 | -0.20 |
| Std. Mean Difference IV Random | 95% CI     | -0.24 | 0.50 | 0.47 | 0.54 | 0.95 | 0.87 | 1.02 | 0.36 | 0.17 | 0.35 | 0.96 | 0.80 | 0.94 | 0.33 | -0.41 | -0.20 |

Abbreviations: CI confidence interval, dfs degrees of freedom, F indicator of statistical heterogeneity, P p value, SD standard deviation, Std. standardized, Tau2 indicator of statistical heterogeneity, Total the number of participants, Z z value, Chi2 Chi2 test for heterogeneity.

* Horizontal lines indicate the 95% CI of each study; diamond, the pooled estimate with 95% CI; multilevel meta-analysis.

Fig. 2 Forest plot main analysis, general population, anxiety
19 patients (ie, ‘frontline healthcare workers’). However, the nature of contact was insufficiently described in the included studies.

Strengths of this review compared with previous publications include the systematic search for comparative prepandemic data for inclusion in pairwise meta-analyses, the stepwise selection of prepandemic studies to ensure best available comparability, and the population-specific analysis of risk and protective factors. One limitation refers to the search methods for pandemic studies (eg, no preprints; no reference lists of reviews) and comparative data (eg, subgroups in general population only partially searched). We had no restrictions regarding the publication format except for the exclusion of preprints which might be viewed as limitation. This restriction might have affected the evidence found in this review compared to others (eg, Cochrane reviews) where preprint articles are included.

The large between-study heterogeneity, a problem shared by previous meta-analyses [20, 24, 32, 33], could not be fully explained by subgroup analyses. This heterogeneity probably resulted from differences between the pandemic studies (eg, countries, sociocultural differences in the perception of mental burden, pandemic outbreak severity, subpopulations, outcome measures) and variability between the comparative studies (eg, study design, outcome measures), respectively. Among the pandemic studies, especially the specific outcome measures used were an important source of heterogeneity. Furthermore, the pandemic and comparative data were heterogeneous (eg, country, population), which could be partially captured by our self-developed tool for the level of comparability and was controlled for by the corresponding sensitivity analysis. We cannot preclude that moderators of effects are present that we, though our best efforts, did not identify and therefore could not control for. Besides, comparative studies with larger sample sizes were preferred, leading to small 95% CIs and a lack of CI overlap with pandemic study findings. Despite the comprehensiveness of this review compared to previous publications, the small number of studies in certain subgroups potentially limited the statistical power (eg, surveys including students).

Apart from specific outcome measures, less recent comparative data, and homogenous sample sizes, the subgroup analyses indicated no consistent determinants of heterogeneity. An elevated level of depression based on the assessment with the PHQ and SDS might – at least for the PHQ-9 – be explained by the high

| Study | Total Mean | SD | Total Mean | SD | Total Mean | SD | Total Mean | SD | Total Mean | SD |
|-------|------------|----|------------|----|------------|----|------------|----|------------|----|
| Bauerle 2020 (PHQ-2) | 15037 | 1.14 | 1.5000 | 15010 | 0.94 | 1.2000 | 0.14 | 0.011 | 0.17 |
| Chang 2020 (PHQ-9) | 3881 | 2.45 | 3.5200 | 1045 | 3.30 | 4.0000 | 2.03 | -0.23 | -0.30 | -0.17 |
| González–Sangaino 2020 (PHQ-2) | 3480 | 1.60 | 1.5000 | 5010 | 0.94 | 1.2000 | 0.50 | 0.45 | 0.54 |
| Guo 2020 (non-infected controls; PHQ-9) | 1183 | 4.36 | 4.5410 | 1045 | 3.30 | 4.0000 | 0.04 | 0.16 | 0.24 |
| Hao F 2020 (controls; DASS-21 depression) | 109 | 2.20 | 3.5000 | 13028 | 2.17 | 3.2600 | 0.01 | -0.18 | 0.20 |
| Iasevoli 2020 (caregivers; PHQ-9) | 51 | 4.20 | 3.2000 | 339 | 4.73 | 5.2600 | -0.10 | -0.40 | 0.19 |
| Iasevoli 2020 (controls; PHQ-9) | 205 | 6.20 | 4.5000 | 1200 | 3.90 | 3.8000 | 0.59 | 0.44 | 0.74 |
| Leu 2020 (SDS) | 1500 | 37.14 | 11.5700 | 18924 | 36.67 | 4.7900 | 0.006 | 0.01 | 0.11 |
| Ma 2020 (DASS-21 depression) | 123 | 4.20 | 3.2000 | 1815 | 2.30 | 3.1000 | 0.62 | 0.44 | 0.81 |
| Mazza 2020 (DASS-21 depression) | 2706 | 5.34 | 4.8100 | 417 | 3.59 | 3.2000 | 0.40 | 0.29 | 0.50 |
| McKay 2020 (DASS-21 depression) | 909 | 2.77 | 3.2100 | 13038 | 2.17 | 3.2600 | 0.18 | 0.12 | 0.25 |
| Odrezoła–González 2020 (DASS-21 depression) | 2500 | 5.52 | 4.9200 | 1055 | 5.45 | 1.7200 | -0.01 | -0.06 | 0.08 |
| Ologoke 2020 (PHQ-2) | 501 | 1.92 | 0.9300 | 11109 | 0.78 | 0.2000 | 0.58 | 0.76 | 0.99 |
| Ozdin 2020 (HADS depression) | 343 | 6.70 | 4.2000 | 2102 | 6.43 | 3.4100 | 0.08 | -0.04 | 0.19 |
| Sakhi 2020 (PHQ-9) | 6550 | 7.43 | 5.0600 | 897 | 9.40 | 6.2470 | -0.38 | -0.45 | -0.31 |
| Satoli 2020 (DASS-21 depression) | 1304 | 3.86 | 4.1900 | 250 | 3.23 | 3.0400 | 0.16 | 0.02 | 0.29 |
| Soraci 2020 (HADS depression) | 249 | 8.90 | 3.6000 | 21644 | 5.90 | 4.4000 | 0.68 | 0.56 | 0.81 |
| Tan W 2020 (DASS-21 depression) | 673 | 21.40 | 4.5000 | 13038 | 2.17 | 3.2600 | -0.02 | -0.10 | 0.06 |
| Tian 2020 (SCL-90 depression) | 1060 | 1.96 | 0.7000 | 1388 | 1.50 | 0.5900 | 0.72 | 0.64 | 0.80 |
| Taipropoulou (Greece, GAD-7) | 2970 | 14.70 | 4.5100 | 2271 | 7.25 | 4.8500 | 1.60 | 1.53 | 1.66 |
| Tull (USA, DASS-21) | 500 | 7.51 | 9.0000 | 499 | 7.50 | 8.2000 | 0.21 | 0.09 | 0.33 |
| Volti 2020 (PHQ-2) | 2427 | 4.17 | 1.4200 | 5010 | 0.94 | 1.2000 | 2.53 | 2.47 | 2.59 |
| Wagner C 2020 (1st survey; DASS-21 depression) | 1210 | 6.30 | 7.2000 | 13038 | 2.17 | 3.2600 | 1.10 | 1.04 | 1.16 |
| Wagner C 2020 (2nd survey; DASS-21 depression) | 861 | 6.40 | 7.4000 | 13038 | 2.17 | 3.2600 | 1.16 | 1.09 | 1.23 |
| Wagner Y 2020 (SDS) | 600 | 40.50 | 11.3100 | 18924 | 36.67 | 4.7900 | 0.50 | 0.42 | 0.58 |
| Yuan R 2020 (child hosp. ped.; HADS depression) | 50 | 7.72 | 2.8100 | 8284 | 5.80 | 4.2600 | 0.46 | 0.16 | 0.74 |
| Yuan R 2020 (child not hosp. ped.; HADS depression) | 50 | 4.54 | 2.5600 | 8284 | 5.80 | 4.2600 | -0.08 | -0.58 | 0.42 |
| Zhou SJ 2020 (PHQ-2) | 8079 | 5.15 | 5.6000 | 1045 | 3.50 | 4.0000 | 0.34 | 0.27 | 0.40 |

Abbreviations: CI, confidence interval; df, degrees of freedom; F, indicator of statistical heterogeneity; P, p value; SD, standard deviation; Std., standardized; Tau², indicator of statistical heterogeneity; Total, the number of participants; Z, z value; Chi², Chi² test for heterogeneity.

* Horizontal lines indicate the 95% CI of each study; diamond, the pooled estimate with 95% CI; multilevel meta-analysis.

**Fig. 3** Forest plot main analysis, general population, depression
| Subgroup analysis (subgroups) | Outcome | Test for subgroup differences$^a$ | Population | Subgroup difference: elevated effect$^b$ | Subgroup difference: reduced effect$^b$ |
|------------------------------|---------|-----------------------------------|------------|------------------------------------------|------------------------------------------|
| **Population characteristics (main studies)** | | | | | |
| Age | Anxiety | Chi² = 9.5, df = 5 (p = .09) | GP | / | / |
| · 30 years | Depression | Chi² = 29.3, df = 5 (p < .001) | GP | ≤ 30 years; > 40 ≤ 45 years | / |
| · > 30 ≤ 35 years | Stress | Chi² = 1043.3, df = 4 (p < .001) | GP | / | > 40 ≤ 45 years |
| · > 35 ≤ 40 years | Anxiety | Chi² = 8.7, df = 4 (p = .07) | HCW | / | / |
| · > 40 ≤ 45 years | Depression | Chi² = 2.2, df = 1 (p = .14) | HCW | / | / |
| · multiple age groups | Sleep | Chi² = 0.3, df = 1 (p = .57) | HCW | / | / |
| · age not specified | Anxiety | Chi² = 17.14, df = 4 (p = .002) | P | > 40 ≤ 45 years | / |
| | Depression | Chi² = 3.74, df = 4 (p = .44) | P | / | / |
| Stressor exposure | Anxiety | Chi² = 2.8, df = 3 (p = .42) | GP | / | / |
| · General population | Depression | Chi² = 1.9, df = 3 (p = .60) | GP | / | / |
| · Students | Stress | Chi² = 0.12, df = 3 (p = .99) | GP | / | / |
| · Others | Anxiety | Chi² = 0.3, df = 2 (p = .88) | P | / | / |
| · Special exposure | Depression | Chi² = 1.3, df = 2 (p = .51) | P | / | / |
| Covid-19 patient contact | Anxiety | Chi² = 0, df = 1 (p = .95) | HCW | / | / |
| · Low contact risk | Depression | Chi² = 1.0, df = 1 (p = .31) | HCW | / | / |
| · High contact risk | Sleep | Chi² = 0.2, df = 1 (p = .69) | HCW | / | / |
| Subgroup of patients | Anxiety | Chi² = 0.3, df = 2 (p = .88) | P | / | / |
| · COVID-19 patients | Depression | Chi² = 1.3, df = 2 (p = .51) | P | / | / |
| · Pregnant women | | | | | |
| · Psychiatric patients | | | | | |
| **Pandemic study characteristics** | | | | | |
| Survey start$^c$ | Anxiety | Chi² = 3.55, df = 4 (p = .47) | GP | / | / |
| · ≤ 4 weeks | Depression | Chi² = 10.15, df = 4 (p = .04) | GP | > 8 weeks | / |
| · > 4 ≤ 6 weeks | Stress | Chi² = 0.31, df = 4 (p = .99) | GP | / | / |
| · > 6 ≤ 8 weeks | Anxiety | Chi² = 7.91, df = 4 (p = .10) | HCW | / | / |
| · > 8 weeks | Depression | Chi² = 0.95, df = 2 (p = .62) | HCW | / | / |
| · not specified | Sleep | Chi² = 4.21, df = 2 (p = .12) | HCW | / | / |
| · Anxiety | Chi² = 4.58, df = 2 (p = .10) | P | / | / |
| · Depression | Chi² = 3.08, df = 3 (p = .38) | P | / | / |
| · Stress | Chi² = 0.10, df = 1 (p = .75) | GP | / | / |
| Study conduction China | Depression | Chi² = 0.60, df = 1 (p = .44) | GP | / | / |
| · China | Stress | Chi² = 0.10, df = 1 (p = .76) | GP | / | / |
| · Non-China | Anxiety | Chi² = 2.84, df = 1 (p = .09) | HCW | / | / |
| | Depression | Chi² = 0.08, df = 1 (p = .78) | HCW | / | / |
| | Sleep | Chi² = 0.32, df = 1 (p = .57) | HCW | / | / |
| | Anxiety | Chi² = 3.35, df = 1 (p = .07) | P | / | / |
| | Depression | Chi² = 0.62, df = 1 (p = .43) | P | / | / |
| Outcome measure | Anxiety | Chi² = 10.7, df = 6 (p = .10) | GP | / | / |
| · AIS | Depression | Chi² = 11.46, df = 5 (p = .04) | PHQ-2 | / | / |
| · BDI | Stress | Chi² = 0.16, df = 1 (p = .69) | GP | / | / |
| · DASS-21 | Anxiety | Chi² = 2.80, df = 4 (p = .59) | HCW | / | / |
| · EPDS | Depression | Chi² = 2.91, df = 3 (p = .41) | HCW | / | / |
| · EPDS-3A | | | | | |
| · GAD-2; GAD-7 | | | | | |
| · HADS | | | | | |

$^a$ Chi² tests for subgroup differences are presented for outcomes with at least 4 studies in the main analysis.

$^b$ Elevated and reduced effect sizes are indicated by subgroups.

$^c$ Survey start categories are categorized as follows: ≤ 4 weeks, > 4 ≤ 6 weeks, > 6 ≤ 8 weeks, > 8 weeks, not specified.
Table 4 Results of subgroup analyses for those populations and outcomes with at least k = 4 studies in main analysis (Continued)

| Subgroup analysis (subgroups) | Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|-------------------------------|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| • HAMA                        | Sleep   | Chi² = 0.32, df = 1 (p = .57) | HCW        | /                                    | /                                    |
| • HAMD                        | Anxiety | Chi² = 1.18, df = 4 (p = .88) | P          | /                                    | /                                    |
| • ISI                         | Depression | Chi² = 16.95, df = 5 (p = .005) | P          | SDS; PHQ-9                            | /                                    |
| • PHQ-2; PHQ-9                |         |                               |            |                                      |                                      |
| • PSQI                        |         |                               |            |                                      |                                      |
| • PSS                         |         |                               |            |                                      |                                      |
| • SAS                         |         |                               |            |                                      |                                      |
| • SCL-90                      |         |                               |            |                                      |                                      |
| • STAI-Y                      |         |                               |            |                                      |                                      |

Sample size
- • < 1000
- • ≥1000

| Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Anxiety | Chi² = 1.86, df = 1 (p = .17) | GP         |                                      |                                      |
| Depression | Chi² = 0.03, df = 1 (p = .86) | GP         |                                      |                                      |
| Stress   | Chi² = 2.31, df = 1 (p = .13)  | GP         |                                      |                                      |

Comparative study characteristics

Sample size
- • ≤500
- • > 1000 ≤ 5000
- • > 5000 ≤ 10,000
- • > 10,000

| Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Anxiety | Chi² = 3.5, df = 4 (p = .48)  | GP         |                                      |                                      |
| Depression | Chi² = 8.6, df = 3 (p = .03)  | GP         |                                      |                                      |

Publication year
- • ≤1 year ago
- • > 1 year ago
- • > 5 years ago
- • > 10 years ago

| Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Anxiety | Chi² = 8.0, df = 5 (p = .16)  | GP         |                                      |                                      |
| Depression | Chi² = 12.4, df = 5 (p = .03) | GP         | < 10 years ago                       | /                                    |

| Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Stress   | Chi² = 11.6, df = 4 (p = .02)  | GP         | ≤ 1 year ago                         | 2 years ago                          |

| Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Anxiety | Chi² = 0.1, df = 2 (p = .97)  | P          |                                      |                                      |
| Depression | Chi² = 3.9, df = 2 (p = .14)  | P          |                                      |                                      |

Pandemic and comparative study characteristics

| Relationship samples sizesd | Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|-----------------------------|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| • Ratio ≥ 2                | Anxiety | Chi² = 10.0, df = 3 (p = .02) | GP         | Ratio ≥ 0.5 < 2                      | /                                    |
|                           | Depression | Chi² = 4.8, df = 3 (p = .19) | GP         |                                      | /                                    |
| • Ratio ≥ 0.5 < 2          | Stress   | Chi² = 0.4, df = 2 (p = .84)  | GP         |                                      | /                                    |
| • Ratio ≥ 0.1 < 0.5        | Anxiety  | Chi² = 4.2, df = 2 (p = .12)  | HCW        |                                      | /                                    |
| • Ratio < 0.1             | Depression | Chi² = 3.8, df = 2 (p = .15) | HCW        |                                      | /                                    |
Table 4 Results of subgroup analyses for those populations and outcomes with at least k = 4 studies in main analysis (Continued)

| Subgroup analysis (subgroups) | Outcome | Test for subgroup differencesa | Population | Subgroup difference: elevated effectb | Subgroup difference: reduced effectb |
|-------------------------------|---------|-------------------------------|------------|--------------------------------------|--------------------------------------|
| Sleep                         | Chi² = 0.32, df = 1 (p = .57) | HCW          | /          | /                                    | /                                    |
| Anxiety                       | Chi² = 17.7, df = 3 (p < .001) | P            | Ratio ≥ 0.5 < 2; Ratio < 0.1 | /                                    | /                                    |
| Depression                    | Chi² = 3.0, df = 3 (p = .39) | P            | /          | /                                    | /                                    |

Abbreviations: AIS Athens Insomnia Scale, BDI Beck Depression Inventory, DASS-21 Depression Anxiety Stress Scale-21, df degrees of freedom, EPDS Edinburgh Postnatal Depression Scale, EPDS-3A Edinburgh Postnatal Depression Scale-Anxiety subscale, GAD Generalized Anxiety Disorder Scale, GP general population, HADS Hospital Anxiety and Depression Scale, HAMA Hamilton Anxiety Rating Scale, HAMD Hamilton Depression Rating Scale, HCW healthcare workers, p p value, P patients, PHQ Patient Health Questionnaire, PPS Perceived Stress Scale, SAS Self-Rating Anxiety Scale, SCL-90 Symptom Checklist-90, SDS Zung Self-Rating Depression Scale, STAI-Y State Trait Anxiety Inventory-Y

a Chi² = test for subgroup differences
b ordered by size of effect estimate (SMD)

Table 5 Risk and protective factors in three populations (mostly frequently reported factors)

| Risk factorsa | Protective factorsb |
|---------------|---------------------|
| General population |                      |
| Mental disorder/or symptoms [44, 49, 51, 52, 58, 64, 69, 74, 78, 82, 83, 116, 132, 135]¹ | Older age [49, 52, 63, 65, 66, 79, 91, 140, 147]¹ |
| Worries about relatives or oneself [51, 57, 64, 66, 74, 75, 80, 89, 82, 83]¹ [48]¹² | Good economic situation [52, 79, 88, 140, 146]¹ |
| Being female [49, 52, 63, 66, 69, 72, 74, 79, 82, 83, 93]¹ [vs 1x being male] | Satisfaction with/level of information on COVID-19 [45, 49, 52, 85, 88, 93]³ |
| Previous (chronic) medical disease [52, 55, 63, 64, 69, 85, 135]¹ | Not being single [66, 80, 88, 86]¹ |
| Being a student [52, 57, 60, 72, 146]¹ | Higher education [50, 52, 66, 146]¹ |
| Personal/social worries about COVID-19 [51, 85, 86, 145]¹ [48]¹² | Social support [52, 140]¹ [48]¹² |
| Physical symptoms [52, 66, 80, 85, 132]¹ | Being male [54, 65, 85]³ |
| Reduced perceived health [50, 57, 80, 85, 132]¹ | |
| No current relationship [57, 80, 81, 146]¹ | |
| Current local outbreak severity [57, 88, 93, 141]¹ | |
| History of stressful situations [52, 58, 63, 147]¹ | |
| Vulnerability to COVID-19 [53, 85, 146]¹ | |
| Health profession [66, 81, 141]¹ | |
| Own or close person’s quarantine [57, 62, 85]³ | |
| Healthcare workers |                      |
| Mental disorder/or symptoms [97, 115, 116, 119, 122]¹ | Older age [98, 110]³ |
| Being female [98, 110, 119, 121]¹ | |
| Concern about infection with COVID-19 [103, 109, 120, 121]¹ | |
| Exposure to COVID-19 patients [94, 110, 115, 119]¹ | |
| Current local COVID-19 severity [94, 118, 141, 107]¹ | |
| Patients |                      |
| (Suspected) COVID-19 [42, 131, 143]¹ | Higher education [127]¹²³ |
| Inflammatory markers in blood [42, 131]¹ | Good economic situation [127]¹²³ |
| Physical symptoms [132]¹ | Higher lymphocyte ratio in blood [42]¹ |
| Concomitant medical diseases [133]¹ | Concomitant medical diseases [133]¹ |
a most frequently reported risk factors: general population: factor was reported as statistically significant risk factor in at least k = 4 studies; healthcare workers: factor reported in at least k = 4 studies; patients: factor reported in at least k = 2 studies
b most frequently reported protective factors: general population: factor was reported as statistically significant protective factor in at least k = 3 studies; healthcare workers: factor reported in at least k = 2 studies (limited number of studies reporting protective factors in this group); patients: factor reported in k = 1 study (limited number of studies reporting protective factors in this group)
on Chinese studies thus potentially limiting the transferability of findings to other contexts.

Further research in other countries (eg, USA), that started later on during the pandemic, could change the findings. The latter is also supported by the wide prediction intervals identified in this review, which indicate uncertainty in our conclusions about whether the pandemic and related stressors do affect mental health [203].

The review has several implications for research and practice. There is an urgent need for representative surveys, in order to allow fair comparisons between the mental burden caused by SARS-CoV-2 in different countries and to examine other risk and protective factors (eg, cultural context). Representative surveys in the general population might also serve to identify specific subgroups at risk for which further studies would be needed. From a public mental health perspective, a stronger focus on (psychosocial) protective factors for mental health would be desirable to derive appropriate contents for preventive measures (eg, pandemic preparedness plans) or health-promoting interventions (eg, resilience training) prior to, during, and after a pandemic [199]. By further investigating the mental health impact of specific stressors – in line with Brooks and colleagues [13] – researchers and practitioners might gain further knowledge about when (eg, in pandemic timeline) and for whom (eg, after exposure to which stressors) interventions should be implemented to buffer negative mental health effects of SARS-CoV-2.

Conclusions
In conclusion, compared with prepandemic data, this review shows different adverse mental health consequences of the early phase of the SARS-CoV-2 pandemic in the examined population groups in contrast to previous research, with healthcare workers being more resilient than expected. The quality of studies varies. High-quality, representative surveys in the general population and specific subpopulations, longitudinal studies, and further research efforts on protective factors are needed to better understand the psychological impacts of the SARS-CoV-2 pandemic and to help design effective preventive measures and interventions that are tailored to the needs of specific population groups.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12992-021-00670-y.

Additional file 1: Methods of the systematic review with meta-analyses. eTable 1. MOOSE Checklist. eTable 2. Differences between protocol.

Abbreviations
COVID-19: Coronavirus disease 2019; LORA: Longitudinal Resilience Assessment; MOOSE: Meta-analyses Of Observational Studies in Epidemiology; NIH: National Institutes of Health; PHQ: Patient Health Questionnaire; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO: International Prospective Register of Systematic Reviews; SARS-CoV(−2): Severe Acute Respiratory Syndrome Coronavirus (−2); SD: Standard deviation; SDS: Zung Self-Rating Depression Scale; SMD: Standardized mean difference

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Authors’ contributions
AMK, NR, JSW, and KL designed the study. NR and LG, respectively, assessed study eligibility; KL was consulted in case of any disagreements. NR and LG extracted and analyzed data for Table 1, with KL being consulted in case of any disagreements. AMK, NR, and GS designed the statistical analyses. AMK and NR analyzed data for Tables 2, 3, 4 and 5 based on pairwise meta-analyses (including subgroup and sensitivity analyses) and the narrative synthesis of risk/protective factors. GS and HB reviewed the statistical analyses. KL monitored the review process. All authors contributed to the interpretation of the results, with special expertise provided in the field of resilience research (AMK, OT, KL), public health (MC, ER), and evidence-based medicine (CS, JMJ). AMK wrote the first draft of the manuscript with input and subsequent edits by all authors. KL is the guarantor. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analyzed during this study are included in this published article and its supplementary information files. Additional data (eg, detailed extracted data) are available from the corresponding author on request.

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