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COVID-19 pandemic-related mortality, infection, symptoms, complications, comorbidities, and other aspects of physical health among healthcare workers globally: An umbrella review

Muhammad Chutiyami[a,*], Umar Muhammad Bello[b,c], Dauda Salihu[d], Dorothy Ndwiga[a], Mustapha Adam Kolo[e], Reshin Maharaj[a], Kogi Naidoo[f], Liza Devar[a], Pratitha Pratitha[a], Priya Kannan[g]

[a] School of Nursing, Institute of Health & Management, Sydney, Australia
[b] Hong Kong Science Park, Centre for Eye and Vision Research (CEVR) Limited, Hong Kong, China
[c] Department of Physiotherapy, Yobe State University Teaching Hospital, Damaturu, Yobe, Nigeria
[d] School of Nursing, The Hong Kong Polytechnic University, Hong Kong, China
[e] Department of Geography, University of Maiduguri, Nigeria
[f] Institute of Health & Management, Melbourne, Australia
[g] Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong, China

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ABSTRACT

Background: The COVID-19 pandemic has continued to cause unprecedented concern across the globe since the beginning of the outbreak. Healthcare workers, particularly those working on the front line, remain one of the most affected groups. Various studies have investigated different aspects of the physical health of healthcare workers; however, limited evidence on the overall physical health of healthcare workers has been collectively examined.
Aim: To examine the various aspects of physical health and well-being of healthcare workers during the COVID-19 pandemic.
Design: An umbrella review.
Methods: We conducted a comprehensive literature search on Academic Search Premier, CINAHL, Cochrane Library and MEDLINE and supplemented the search with Google Scholar. Key terms related to 'COVID-19', 'physical health', 'healthcare worker' and 'systematic review' were used in the search. Systematic reviews with or without meta-analyses were included if they were published in the English language, could be obtained in full-text format, and assessed the physical health impacts of the COVID-19 pandemic on healthcare workers were included. The methodological quality of eligible studies was assessed using the Joanna Briggs Institute's checklist for systematic reviews. The data were narratively synthesised in line with the 'Synthesis Without Meta-analysis' guideline.
Results: Thirteen systematic reviews (represented as $K = 13$) that synthesized data from 1230 primary studies/reports and 1,040,336 participants met the inclusion criteria. The findings indicate a death rate of between 0.3 and 54.2 per 100 infections ($K = 4$). The overall case-fatality rate was estimated to be 0.87% (approximately 9 deaths per 1000 infections, $K = 3$). The overall infection rate among healthcare workers ranged from 3.9% to 11% ($K = 5$), with the highest rate associated with healthcare workers involved in screening. Considering geographic regions, the highest number of infections was reported in Europe (78.2% of 152,888 infected healthcare workers, $K = 1$). More nurses and female healthcare workers were infected, while deaths occurred mainly among men and medical doctors. The commonly reported symptoms included cough (56–80%, $K = 3$), fever (57–85%, $K = 3$), and headache (7–81%, $K = 3$), while hypertension was the most prevalent comorbidity (7%, $K = 1$). Additionally, a high prevalence of poor sleep quality (41–43%, $K = 2$), work-related stress (33–44.86%, $K = 5$) and personal protective equipment-associated skin injuries (48.2–97%, $K = 2$) affected the healthcare workers. The most reported preventive measures included laboratory testing, clinical diagnosis, adequate personal protective equipment, self-isolation, and training/orientation for infection control.

* Corresponding author.
E-mail address: muhammad.c@ihm.edu.au (M. Chutiyami).

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Conclusion: Healthcare workers experienced considerable COVID-19-related physical health issues, including mortalities. This requires targeted interventions and health policies to support healthcare workers worldwide to ensure timely management of the pandemic.

Tweetable abstract: This umbrella review highlights the global mortalities, infections, and other aspects of physical health of healthcare workers during the COVID-19 pandemic.

What is already known

- COVID-19 pandemic is associated with increasing cases of mortality and morbidity among healthcare workers globally.
- The impact of COVID-19 on the overall physical and mental wellbeing of healthcare professionals remains unclear due to the rapid changes in the COVID-19 disease trajectory.

What this paper adds

- An overall case fatality rate of approximately 9 deaths per 1000 infections, with an infection rate of 14.5% was estimated among healthcare workers.
- The most common SARS-CoV-2 infection symptoms among healthcare workers were cough, fever, and headache, while hypertension was the most prevalent comorbidity.
- Poor sleep quality, work-related stress and skin injuries associated with use of personal protective equipment were additional physical health issues found among about one-third of the healthcare workers during the COVID-19 pandemic.

1. Introduction

The novel virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has continued to be a global health threat since the COVID-19 outbreak was declared a pandemic by the World Health Organization (WHO) in March 2020. As of 17 September 2021, over 226 million cases and 4.6 million deaths associated with COVID-19 have been documented globally (WHO, 2021). The disease burden is ongoing, with continued uncertainty (Koffman et al., 2020) coupled with the emergence of variants of the virus that are more infectious (Centers for Disease Control and Prevention, 2021). Additionally, the emergence of the new SARS-CoV-2 variants is raising concerns about the effectiveness of COVID-19 vaccines (Robinson et al., 2021), which necessitates more research.

With the ongoing threat of COVID-19 to healthcare systems and society at large, various strategies to prevent and reduce the spread of SARS-CoV-2 have been implemented. Such strategies, including quarantine, social isolation, and total lockdowns, have been introduced in many countries to contain the spread of the virus. However, studies have reported an increase in psychological distress due to isolation; the physical symptoms of COVID-19, such as cough, dyspnoea, and fever; and the side effects of COVID-19 treatments (Wang et al., 2020). Although, certain population groups such as ethnic minorities (Kirby, 2020) and people with pre-existing chronic conditions (Garg et al., 2020), are disproportionately affected, healthcare workers are at an increased risk of contracting COVID-19 compared to the general population (Nguyen et al., 2020). Healthcare workers are also at an increased risk of physical disorders, including mortalities; psychological disorders; and poor health outcomes (David et al., 2021; Saragih et al., 2021; Yifan et al., 2020; Yunitri et al., 2022) due to extreme pressure from workloads or working longer hours (Yifan et al., 2020), isolation from family members and indirect COVID-19 complications such as personal protective equipment-related injuries (Battista et al., 2021).

Various systematic reviews have been conducted to explore specific aspects of the physical health of healthcare workers during the COVID-19 pandemic. These include, for instance, systematic reviews on COVID-19-related infections/deaths (Sahu et al., 2020), risk factors (Gómez-Ochoa et al., 2021) and complications (Gross et al., 2021). These systematic reviews have been conducted during different stages of the outbreak and have focused on different constructs of physical health; the consolidation of these findings is of paramount importance to provide comprehensive evidence regarding the physical health issues among healthcare workers to guide policymakers and other stakeholders as they allocate resources, develop, and implement tailor-made training of healthcare workers and interventions. Therefore, the present review, referred to as umbrella review (Aromataris et al., 2015), aims to synthesize and analyze the existing evidence on the overall physical health and well-being among healthcare workers during the COVID-19 pandemic.

2. Methods

The review was registered with the international prospective register of systematic reviews (PROSPERO) as part of a mega-review on the overall impact of COVID-19 among healthcare workers (Reference: CRD42021262001). The review question was formulated using a PEO (Population, Exposure, Outcome) framework. The population comprised nurses, medical doctors, dental professionals, physiotherapy, and other unclassified healthcare professionals. The 'exposure' was COVID-19, while the 'outcome' includes the various aspect of physical health of the healthcare workers.

2.1. Eligibility criteria

Systematic reviews with or without meta-analyses were included if they were published in the English language, could be obtained in full-text format, and assessed the physical health impacts of the COVID-19 pandemic on healthcare workers (nurses, medical doctors, dental professionals, physiotherapists, and other healthcare professionals not classified). Scoping reviews and rapid reviews were included if they employed key systematic approaches in the review process, including a predefined search strategy, screening, data extraction and synthesis. Systematic reviews that synthesised data from previous pandemics but reported separate COVID-19-related findings were also included, as were systematic reviews that included the general population but performed a separate analysis on healthcare workers. Exclusion criteria included primary studies, non-systematic narrative reviews, traditional literature reviews, reviews assessing the impacts of COVID-19 on non-health professionals and non-COVID-19-related studies.

2.2. Information sources

A comprehensive search of four electronic databases (Academic Search Premier, CINAHL Complete, Cochrane Database of Systematic Reviews and MEDLINE Complete) was conducted to identify eligible studies examining the various aspect of physical health of healthcare workers during the COVID-19 pandemic. The search was supplemented with a Google Scholar search (first 10 pages), and a ‘snowballing’ approach was used to identify additional resources from reference lists and citation checks. The search was not restricted by a publication start date, and all databases were searched until June 2021.

2.3. Search strategy

The identified databases were searched using applicable medical subheadings (MeSH) and index terms to identify relevant systematic reviews. Boolean operators and truncations were also used as appropriate. EBSCOhost was used to search the Academic Search Premier, CINAHL Complete and MEDLINE Complete databases using the same search terms: (COVID-19 OR Coronavirus OR SARS-COV2) AND (“physical health” OR infection OR symptom OR mortalit* OR complication OR comorbid* OR “sleep quality” OR wellbeing) AND (“healthcare worker*” OR “health professional*” OR nurse* OR physician* OR “medical doctor” OR “medical staff”) AND (“systematic review” OR “rapid review” OR “scoping review”). The Cochrane Database of Systematic Reviews was searched using a combination of (“healthcare worker*” OR “medical staff” OR “health professional*” OR nurse* OR physician* OR “medical doctor” OR dentist OR physiotherapist) AND (COVID-19 OR Coronavirus OR SARS-COV2). The search on Google Scholar was conducted using the term ‘covid-19 healthcare worker physical health’. The search was limited to articles published in the English language.

2.4. Selection of eligible studies

The predefined eligibility criteria were applied to the selection process, which involved the sequential screening of the titles, abstracts and full texts of the systematic reviews identified in the electronic database search. Two of the reviewers (MC and DS) screened the studies independently according to the predefined inclusion and exclusion criteria. Differences were resolved by discussion, and a third reviewer (UMB) was involved if an agreement was not reached. The selected studies were systematic reviews examining any aspect of physical health among healthcare workers during the COVID-19 pandemic.

2.5. Data extraction

Data extraction was performed using a Microsoft Excel package specifically designed to meet the aim of the review. The extraction form was designed by three reviewers (MC, UMB and DS) and included authors’ details, the aims of the review/research question(s), types of primary studies included in the review, geographic location of primary studies included in the review, the cadre of health professionals (e.g., nurses, physicians) assessed in the review, specific mental health domains assessed, measures/instruments used for the assessments, detailed results, and authors’ conclusions. Two reviewers (LD and PP) extracted the data from the included studies. Differences were resolved through discussion between the two reviewers. A third reviewer (DN) cross-checked all the extracted data for accuracy and completeness.

2.6. Data items

Outcome variables included mortality, infection, clinical symptoms, complications, comorbidities, skin injuries, poor sleep quality and work-related stress. Mortality was reported as a raw number and as a rate of death within several infected healthcare workers, where available. For reviews with available data, a case fatality rate was estimated and reported in the current review as a percentage of deaths per infection. Infection was also reported as a raw number and as a rate among all healthcare workers (infected and uninfected) or among the general population (healthcare workers and non-healthcare population). Clinical symptoms, complications, comorbidities, and skin-related injuries were reported as overall estimates among the infected healthcare workers. Poor sleep quality and work-related stress were reported as prevalence rates, and where available, the measurement tool/instrument was specified.

2.7. Critical appraisal of the included studies

Quality appraisals of the included studies were performed using the Joanna Briggs Institute (JBI) checklist for systematic reviews (JBI, 2017). The instrument consists of 11 items that assess different aspects of a systematic review, each of which can be answered using the options ‘Yes’, ‘No’, ‘Unclear’ or ‘Not Applicable’ (JBI, 2017). An appraisal of each included systematic review was conducted independently by two reviewers (MC and MAK). Discrepancies were resolved by further discussions between the reviewers. For this review, the number of items receiving a ‘Yes’ answer for each study was counted and used to determine the quality of the included review. Because the JBI checklist for systematic reviews does not provide a classification guideline for determining study quality, we categorised the quality of the articles by dividing the 12 possible scores (0–11 inclusive) into 3 categories representing poor quality (0–3), medium quality (4–7) and high quality (8–11).

2.8. Synthesis of results

A meta-analysis was deemed inappropriate for this meta-review, as some of the included studies were already meta-analyzed. Therefore, an in-depth narrative synthesis was undertaken by three of the reviewers (MC, UMB and DS). The analysis followed the synthesis without meta-analysis (SWiM) guidelines (Campbell et al., 2020).

This analysis involved a detailed examination of the narrative and numeric summary findings and the reported conclusions regarding the effect of the COVID-19 pandemic on any aspect of physical health of the healthcare workers (nurses, medical doctors, dental professionals, physiotherapists, and other unclassified healthcare professionals). The key results were presented in a table that included the nature of the effect and the effect sizes. The overall nature of the effect of the COVID-19 pandemic on physical health issues was reported for the studies that did not include a comparison with a non-healthcare population. For studies that reported a comparison against a non-healthcare population, the result was reported as either significant or non-significant. Where available and possible, the effect sizes, study designs included in the systematic reviews (narrative synthesis or meta-analysis) and quality of the systematic review were considered when making conclusions.

For all findings and where applicable, a p-value of < 0.05 was considered statistically significant with a 95% confidence interval (CI).

3. Results

3.1. Selection of included studies

The initial search of the four databases (Academic Search Premier, CINAHL, MEDLINE and Cochrane) resulted in the identification of 346 articles, and the supplemental search performed on Google Scholar generated 6 relevant articles, resulting in a total of 352 articles. Duplicate articles were removed, and an English

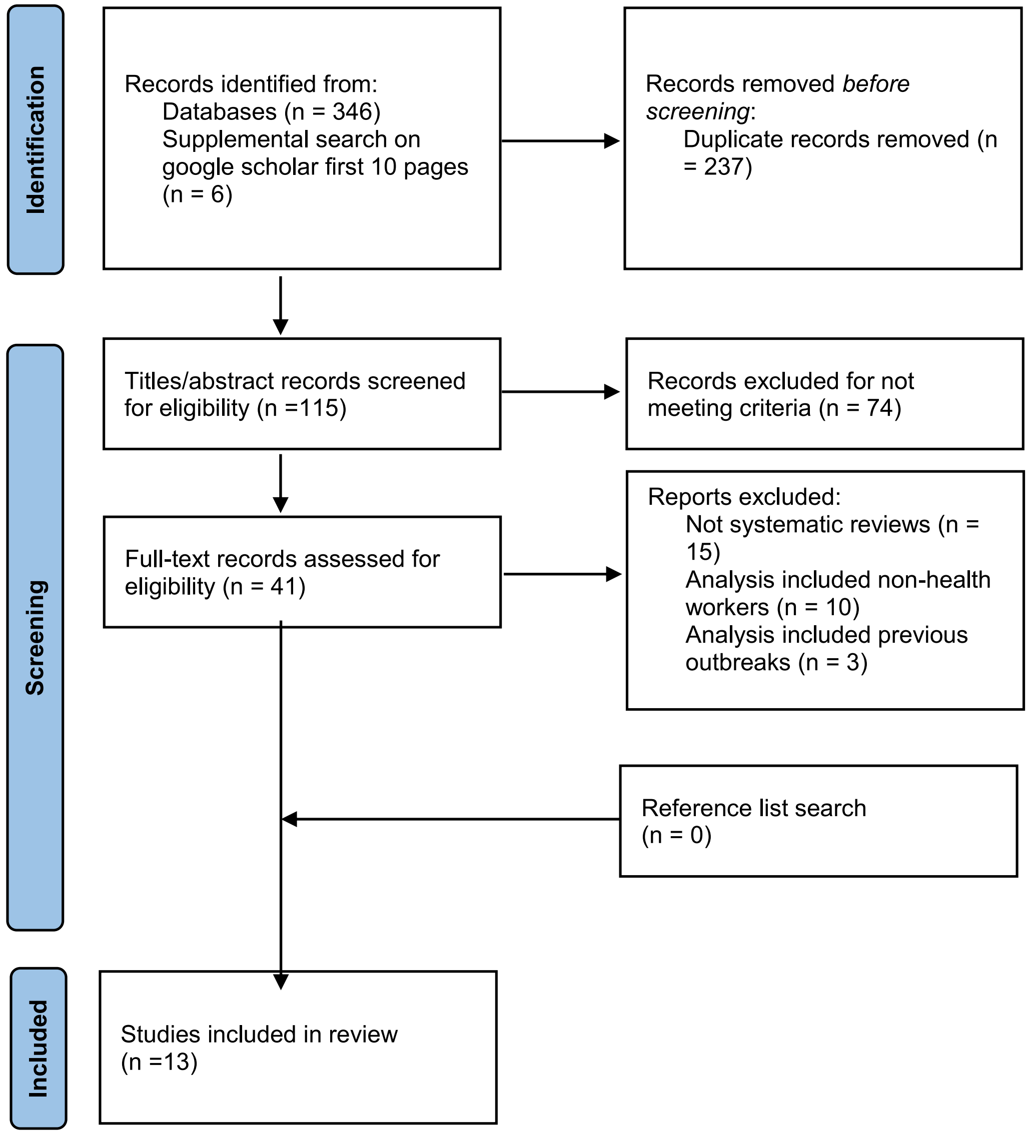

Fig. 1. PRISMA flow chart indicating the study selection process.

language limitation was applied to the database search, which reduced the list to 115 articles. The titles and abstracts of these 115 articles were screened against the eligibility criteria, resulting in the identification of 41 articles that potentially met the inclusion criteria. The full texts of the remaining 41 studies were retrieved and screened for eligibility. Finally, 13 studies were identified as fully meeting the eligibility criteria. The reference lists of these 13 studies were reviewed; however, this did not result in the identification of an additional study. Therefore, 13 systematic reviews were included in the current review. The study selection process is reported in Fig. 1.

3.2. Characteristics of the included studies and participants

The 13 reviews included in this study consisted of 1230 individual studies with a total population of 1040,336 (Table 1). The study by Moitra et al. (2021) reported studies with sample sizes ranging from 52 to 14,825 (n = 1, 7.7%), while the study by Kunz et al. (2021) did not report their sample size. Although six studies did not report the gender distribution of the participants in their studies, seven other studies reported on gender; female participants constituted 20.5% (n = 213,571) and male participants constituted 6.4% (n = 66,857) of the total study population. The age of the participants in the primary studies ranged from 15 to 84 years (including both health professionals and the general public). The primary studies in the included systematic reviews were published between November 2019 and March 2021. The commonly used databases were PubMed (n = 8, 61.5%) and Medline (n = 8, 61.5%), followed by Embase (n = 6, 46.2%), Web of Science (n = 6, 46.2%) and Google Scholar (n = 6, 46.2%). Except for two studies that reported on both healthcare workers and the general population, all the studies were solely conducted on healthcare professionals (n = 11, 84.6%). The commonly used study designs were cross-sectional (n = 8, 61.5%) and qualitative (n = 4, 30.8%). Three reviews did not specify the qualities of their included studies, two reported their quality in a range of 1–5 (n = 1, 7.7%), and low, moderate to high quality (n = 1, 7.7%) while others reported a low to moderate (n = 2, 15.4%), good (n = 2, 15.4%), moderate to high (n = 1, 7.7%), moderate (n = 1, 7.7%), fair (n = 1, 7.7%) or high-risk (n = 1, 7.7%) quality of studies. The commonly used quality assessment tools were the JBI checklist (n = 2, 15.4%), the Newcastle-Ottawa Scale (NOS; n = 2, 15.4%), the Appraisal tool for

Table 1
Characteristics of Included studies and participants.

No	Author	Year	Gender/age (years)	Search strategy	Studies included/and participants	Outcomes/validated tool	Risk of bias/Instrument used	Country of studies	Comorbidities
1	Al Maqbali et al.	2021	Age: NR Sex: NR	Databases used: PubMed, CINAHL, Medline, Embase, PsycINFO, MedRxiv and Google Scholar. Search period: January 2020 to October 2020. Eligibility: 1) studies reporting the prevalence any of stress, anxiety, depression, or sleep disturbances on nurses. 2) All types of settings, 3) cohort or cross-sectional surveys.	Number of studies included: 93 Number of participants: 93,112 Population: Nurses Design: Cross-sectional Settings: Hospital (n = 67); Mixed (n = 17); undefined (n = 9)	Depression, stress, anxiety, and sleep disturbances/validated tool (DASS-21, SCL-90, IES-R, GAD-7, PHQ-4, 9; PSS-4, ISI, SRQ-20, SAS, SDS, PCL-5, HADS, PSQI, PTSD, SOS, ASDI, BDI, HAM-A, STAI, SRSS, WSP, PDSS, BAI, CAS, AIS, and NSS).	Low-medium quality studies/NOS checklist	Austria, Bahrain, Bolivia, China, Croatia, Ecuador, Egypt, Ethiopia, France, Germany Greece, Iran, Italy, Jordan, Korea, Kosovo, KSA, Malawi, Mongolian, Nepal, Pakistan Peru, Poland, Portugal, Russia, Singapore Spain, Switzerland, Turkey, UK, USA	None
2	Bandyopadhyay et al.	2020	Age: 18–84 years Sex: Male: 28.4% (n = 5806) Female: 71.6% (n = 14 656)	Databases used: Medline and Embase Search period: 17 November 2019 to 8 May 2020 Eligibility: all studies on healthcare workers with primary data.	Number of studies included: 594 Number of participants: 152,888 Population: Support staff: 6.8% (n = 1899); Doctor: 31.3% (n = 8688); Nurse: 38.6% (n = 10 706); Administrators: <0.1% (n = 29); Midwives: <0.1% (n = 9); Allied health professionals: 23.1% (n = 6394); Design: NR	Number of healthcare workers infected/died with COVID-19	Good/AACODS checklist or NIH study quality assessment tool	Afghanistan, Algeria, Argentina, Armenia, Australia, Austria, Bahamas, Bangladesh, Belgium, Bosnia-Herzegovina Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Crotia, Cuba, Cyprus, Czechia, Denmark, Dominican-Republic, Ecuador, Egypt, Estonia, Finland, Germany, Ghana, France, Greece, Guyana, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Kazakhstan, KSA, Kuwait, Kyrgyzstan, Lithuania, Malaysia, Maldova, Mexico, Netherlands, New Zealand, Niger, Nigeria, Pakistan, Panama, Peru Philippines, Poland, Portugal, Romania, Russia, Serbia, Slovenia, South Africa, South Korea, Spain, Tajikistan, Thailand, Tunisia, Turkey, UK, Ukraine, Uruguay, USA	None
3	de Pablo et al.,	2021	Age: Mean age was 36.1 ± 7.1 years; ranges from 23 to 69.4years. Sex:females (n = 49,697, 77.1%); males (n = 14,761, 22.9%)	Databases used: The Russian Science Citation Index, the BIOSIS Citation Index, Web of Science Core Collection, the KCI-Korean Journal Database, MEDLINE, and the SciELO Citation Index, Search period: from inception. until 15th April 2020. Eligibility: 1) Primary studies, 2) healthcare professionals exposed to COVID-19, ARS/MERS, 3) mental or physical health outcomes, 4) written in the English language, and 5) have >5 samples.	Number of studies included: 115 Number of participants: 64,458. Population: healthcare professionals. Design: quantitative & qualitative study designs.	Psychological distress, anxiety, depressive symptoms, PTSD, burnout, fear, stigmatization feelings, general health concerns, Insomnia, and somatisation/ Self-administered questionnaires, interviews/evaluations, or surveys.	Quality ranged from 1 to 5 (MMAT score)	Canada China Hong Kong Italy Singapore Taiwan Vietnam	None

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Table 1 (*Continued*).

No	Author	Year	Gender/age (years)	Search strategy	Studies included/and participants	Outcomes/validated tool	Risk of bias/Instrument used	Country of studies	Comorbidities
4	Gómez-Ochoa et al.	2021	Age: Mean age 40 Sex: NR	Databases used: the World Health Organization COVID-19 database, Caribbean Health Sciences Literature (LILACS), Embase, Medline, Web of Science, Google Scholar, Cochrane, and the University of Bern Institute of Social and Preventive Medicine database. Search period: until July 8, 2020 Eligibility: 1) all observational studies, 2) studies reporting the prevalence of COVID-19 on healthcare professionals, or 3) studies evaluating the associated risks factors for SARS-CoV-2 infection.	Number of studies included: 97 Number of participants: 230,398 Population: healthcare workers Design: All observational studies (eg, cross-sectional, cohort, case-control studies, and case series).	Prevalence, and associated factors of SARS-CoV-2 infection in healthcare professionals/NR	Moderate quality (n = 61, 62.9%), and high quality (n = 29, 29.9%), low quality (n = 7, 7.2%)/NR	Belgium, China, France, France, Germany, India Italy, Mexico, Netherlands Singapore, South Korea, Spain, UK, USA	Hypertension, cardiovascu-lar disease, type 2 diabetes, and chronic obstructive pulmonary disease
5	Gross et al.	2021	Age: NR Sex: NR	Databases used: PubMed, Web of Science and PsycINFO Search period: 26 April 2020 Eligibility: (1) studies on COVID-19-related psychological and physical health outcomes in HCW (2) studies investigating measures for preventing COVID-19 risks.	Number of studies included: 27. Number of participants: 41,045. Population: healthcare workers. Design: Cross-sectional studies (n = 19, 70.4%), editorial reports (n = 3, 11.1%), retrospective studies (n = 2, 7.4%), and qualitative (n = 2, 7.4%).	Prevalence and severity of infections, risk factors, mortality rates, physical and psychological burden, depression, anxiety, distress, PTSD, somatisation, obsessive-compulsive disorder, Self-efficacy, Stress, anxiety dreams, sleep quality or insomnia/SDS, SAS, DASS-21, IES-R, CES-D, PSQI, PHQ-9, GAD-7, ISI, NRS, HAMA, HAMD, SOS, DASS-21, GSES, SASR, SF-36, SCL-90R, PHQ-4.	Low to moderate quality/AXIS tool, CASP checklist, JBI Critical Appraisal Checklist and GRADE Studies were appraised by the CASP qualitative checklist.	China Germany India Iran Pakistan Singapore USA	None
6	Krishnamoorthy et al.	2020	Age: mean age 30.6 to 49.9 years Sex: NR	Databases used: Chinese, Google Scholar, Medline, national knowledge Infrastructure, Cochrane library, and ScienceDirect. Search period: until 22 April 2020. Eligibility: (1) all studies irrespective of settings, (2) studies on healthcare professionals and the general population, (3) assessing psychological outcomes and impact of events.	Number of studies included: 50 Number of participants: 171,571 Population: general population & healthcare professionals. Design:cross-sectional studies.	sleep quality, stress, psychological distress, insomnia, post-traumatic stress symptoms, anxiety, depression/ validated tool (PCL-C, GAD, PHQ, SDS SAS, GHQ, PSS, WHO, CES-D, PSQI, PTSD-SS HADS, IES-R, ISI, SRQ, HAMD, HAM-A, SOS, AIS, CPDI, GPS, DASS, GSI).	High risks of bias/NOS	China Iran Italy Singapore Vietnam	None

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Table 1 (*Continued*).

No	Author	Year	Gender/age (years)	Search strategy	Studies included/and participants	Outcomes/validated tool	Risk of bias/Instrument used	Country of studies	Comorbidities
7	Kunz et al.	2021	Age: NR Sex: Female (n = 33,450).	Databases used: NR Search period: March 2020 to January 2021. Eligibility: (1) original studies conducted in Europe, North America and Australia, (2) conducted among healthcare professionals, (3) using a validated outcome measure.	Number of studies included: 27 Number of participants: NR Population: nurses & doctors. Design: unspecified	Depression, anxiety, stress, sleep, post-traumatic stress, burnout, substance use disorder, and somatization/validated tools (HADS, PHQ-9, PHQ-8, DASS-21, BDI, PHQ-2, GAD-7, GAD-2, SAS, HARS, ISI, IES-R, PSS-14, STAI-Y, EASE, GPS, PCL-5, PDEG, ProQOL-5, MBI, PFI, CAGE-AID).	NR/JBI-checklist	Australia Belgium Croatia France Germany Italy Italy Spain UK USA	None
8	Lee et al.	2020	Age: median age 62.0years Sex: Female (n = 2128, 53.9%); Male (n = 1820, 46.1%).	Databases used: EMBASE, Medline, PubMed, and Cochrane Central Register of Controlled Trials (CENTRAL). Search period: from inception to April 2020, which continuous till May 29, 2020 Eligibility: (1) studies that reported the outcomes of () on patients undergoing surgical procedures during lockdown periods in hospitals, (2) studies that investigated the impact of lockdown on healthcare workers (surgical).	Number of studies included: 61 Number of participants: 3948 Population: healthcare workers Design: 16 case series, 34 retrospective studies, 6 prospective studies, and 5 descriptive studies.	Types of surgical procedures performed (elective, urgent, or oncologic), the incidence of infected patients (confirmed or presumed) for COVID-19, SARS, MERS, and Ebola, number of negative infections, types of personal protective effective equipment used/NR	Fair quality/MINORS	Canada, China, France Germany, Hong Kong, India, Israel, Italy, Korea KSA, New Zealand, Portugal, Sierra Leone Singapore, Spain, UK USA	None
9	Mahmud et al.	2021	Age: 15–28years Sex: males (n = 43,351, 30%); females (n = 101,118, 70%).	Databases used: MEDLINE, PubMed, Web of Science, and Google Scholar databases. Search period: March 30, 2021. Eligibility: 1) studies on the prevalence of depression, anxiety, and insomnia, (2) health workers, (3) in the English language, (4) observational studies, and (5) with full-text available.	Number of studies included: 69 Number of participants: 144,649 Population: healthcare professionals Design: cross-sectional study	Depression, anxiety, insomnia/ validated tools (CES-D, DASS-21, HADS, PHQ, and SDS, ISR, HAMD, FCV-19S, PDI, PHQ-4, PSSQ EASE, PHQ-15, SAVE-9, BAI, ISI, PSQI, GAD, HAM-A, IES, PSS, PTSD-8, and AIS.	Average STROBE score 21.54/STROBE checklist	Australia, Bangladesh, Canada, China, Croatia, Egypt, Finland, Germany, Ghana, Greek, India, Iran, Italy, Jordan, Korea, KSA, Lebanon, Nepal, Oman, Pakistan, Philippines, Poland, Singapore, South Korea, Spain, Turkey, UK, USA, Vietnam	None
10	Moitra et al.	2021	Age: NR Sex: Female (n = 64%)	Databases used: PubMed and Embase. Search period: Dec 2019–June 2020. Eligibility: (1) studies reporting qualitative and quantitative data reporting mental or psychological healthcare on healthcare professionals.	Number of studies included: 51 Number of participants: overall samples not reported; individual studies samples ranged from 52 to 14,825. Population: healthcare professionals. Design: cross-sectional studies (88%).	Anxiety symptoms, depressive symptoms, sleep quality, psychological trauma, insomnia, workplace burnout, fatigue, and distress/validated tools (PHQ, and GAD were the most commonly used measures; others were the PSQI).	NR	Brazil, Canada, China, India, Iran, Italy, KSA, Kuwait, Lebanon, Pakistan, Romania, Serbia, South Korea, Spain, Sweden, Taiwan, UK, USA	None

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Table 1 (*Continued*).

No	Author	Year	Gender/age (years)	Search strategy	Studies included/and participants	Outcomes/validated tool	Risk of bias/Instrument used	Country of studies	Comorbidities
11	Sahu et al.	2020	Age: NR Sex: NR	Databases used: Web of Science, PubMed, and EMBASE Search period: December 2019 to April 2020 Eligibility: 10 studies reporting the number of positive COVID-19 cases among healthcare workers and patients.	Number of studies included: 11 Number of participants: 119,216 patients out of which 13,199 were healthcare professionals. Population: general public and Health care workers Design: cross-sectional studies	Number of healthcare workers infected with COVID −19, critically and severely ill and healthcare workers/NR	Good quality/AXIS tool	China Italy USA	None
12	Shaukat et al.	2020	Age: NR Sex: NR	Databases used: PubMed and Google Scholar Search period: January to March 2020 Eligibility: 1) articles published in the English language, 2) healthcare professionals.	Number of studies included: 10 Number of participants: 5410 Population: healthcare professionals Design: cross-sectional studies	Depression, anxiety, insomnia, and distress/validated tools (IES-R, PTSD-rating scale, ISI, GAD-7, SASR, Self-rating scale, GSES, and social support rating scale.	NR	China Hong Kong Singapore	None
13	Varghese et al.	2021	Age: 21–45 years Sex: Females (n = 12,522, 91.8%), males (n = 1119, 8.2%).	Databases used: PUBMED, MEDLINE, Psych Info, Google Scholar, Nursing and Allied Health Database, Science Direct, Corona Virus Research Database and Web of Science Core Collection. Search period: March to October 2020. Eligibility: (1) nurses working in a hospital anywhere in the world, (2) exposure or interventions using a validated outcome measure for the assessment of mental health, (3) published in the English language.	Number of studies included: 25 Number of participants: 13,641 Population: nurses Design: cross-sectional studies.	Depression, anxiety, stress, PTSD, and insomnia/validated tools (GAD, SAS, CAS, GSI, STAI, HADS, SASRQ, GSI, PHQ-9, DASS-21, IES, PCL-C, PSS, HAMD and Self-reported Stressor and Incidence Questionnaire).	Moderate to high quality/Loney criteria	Brazil China Croatia Germany India Iran Italy Jordan Oman Philippines Poland Russia Singapore Turkey Vietnam	None

NOS=Newcastle-Ottawa Scale; PTSD=Post-traumatic stress disorder; PSS=Perceived Stress Scale; IES=Impact of Event Scale; DASS-21=Depression Anxiety Stress Scale; GHQ-28=28-item General Health Questionnaire; BDI=Beck Depression Inventory; GSES=General Self-Efficacy Scale; SASRQ=Stanford Acute Stress Reaction Questionnaire; PSQI=Pittsburgh Sleep Quality Index; ISI=Insomnia Severity Index; NR=Not Reported; BAI=Beck's Anxiety Inventory; GAD-7=General Anxiety Disorder 7-items; WHO-5=WHO-Five Well- Being Index; SDS=Self-Rating Depression Scale; HADS=Hospital Anxiety and Depression Scale; IES-*R*=Impact of Event Scale-Revised; GPS-PTSS=Global Psychotrauma Screen, SCL-90=Symptom Check-List 90; SCL-90-R=Symptom Check List-90-revised;; HAM-*A*=Hamilton Anxiety Scale; HAMD=Hamilton Depression Scale; PHQ=Patient Health Questionnaire; SAS=Zung's self-rating anxiety scale; AIS=Athen's Insomnia Scale; SOS=Stress Overload Scale; STAI=State-Trait AnxietyInventory; MBI=Maslach Burnout Inventory; CES-*D*=centre for Epidemiologic Studies Depression Scale; SRQ=Stress Reaction Questionnaire; PTSD-SS=post-traumatic stress disorder self-rating scale; CASP=Critical Appraisal Skills Programme appraisal tool; JBI-checklist=Joanna Briggs Institute checklist; PSS-10=Perceived Stress Scale; PSS-14=Perceived Stress Scale; GSI=Global Severity Index; HARS=Hamilton Anxiety Rating Scale; STAI-*Y*=State Anxiety Inventory-trait form; EASE=Acute Stress of Health Professionals Caring COVID-19 scale; PCL-5=Post-traumatic Checklist-5; PDEG=Peritraumatic Dissociation Questionnaire; ProQOL-5=Professional Quality of Life Scale; PFI=Stanford Professional fulfilment Index; CAGE-AID=Substance Abuse screening tool; CPDI CoViD-19=Peritraumatic Distress Index; GPS-PTSD=Global Psychotrauma Scale-posttraumatic stress disorder subscale; SASR=Stanford Acute Stress Reaction; STROBE checklist=Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statements; ASDI=Acute Stress Disorder Inventory; SRSS=Sleep Self-Assessment Scale; WSP=Work Stress Profile; PDSS=Panic Disorder Severity Scale; CAS=Coronavirus Anxiety Scale; MMAT=Mixed Method Appraisal Tool; ISR= ICD-10-Symptom-Rating; PSSQ=Postpartum Social Support Questionnaire; PDI= Pain Disability Index; SAVE-9=Stress and Anxiety to Viral Epidemics – 9; PTSD-8=Short PTSD Inventory; NSS= Nursing Stress Scale; AXIS=Appraisal tool for Cross-Sectional Studies; USA=United States of America; UK=United Kingdom; KSA=Kingdom of Saudi Arabia.

Table 2
Outcome of the critical appraisal of the included studies.

S/ no	Study refs.	Criteria assessed based on JBI checklist											Total criteria met	Quality ranking
		1	2	3	4	5	6	7	8	9	10	11		
1	Al Maqbali et al. (2021)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	9	High
2	Bandyopadhyay et al. (2020)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	10	High
3	De Pablo et al. (2020)	Y	Y	Y	Y	Y	U	Y	Y	N	Y	N	8	High
4	Gómez-Ochoa et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	U	9	High
5	Gross et al. (2021)	Y	Y	Y	Y	Y	U	U	Y	N	Y	Y	8	High
6	Krishnamoorthy et al. (2020)	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	N	9	High
7	Kunz et al. (2021)	Y	Y	U	N	Y	Y	N	Y	N	Y	N	6	Medium
8	Lee et al. (2021)	Y	Y	Y	Y	Y	U	Y	Y	N	Y	Y	9	High
9	Mahmud et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11	High
10	Moitra et al. (2021)	Y	Y	Y	Y	U	U	Y	Y	N	Y	U	8	High
11	Sahu et al. (2020)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	10	High
12	Shaukat et al. (2020)	Y	Y	Y	N	U	U	U	Y	N	Y	N	5	Medium
13	Varghese et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11	High

Criteria 1 to 11- 1: clarity of review question; 2: appropriateness of inclusion criteria; 3: appropriateness of search strategy; 4: adequacy of search sources; 5: appropriateness for criteria in appraising included studies; 6: appraisal conducted by 2 or more reviewers independently; 7: methods to minimize errors in data extraction; 8: appropriate methods to combine studies; 9: assessment of publication bias; 10: recommendation for policy/practice based on reported data.

Cross-Sectional Studies (AXIS; $n = 2$, 15.4%), and Mixed Methods Appraisal Tool (MMAT scale; $n = 1$, 7.7%).

3.3. Critical appraisal of included studies

The included systematic reviews were evaluated using quality assessment criteria, with scores ranging from 5/11 to 11/11 based on the JBI checklist (Table 2). The majority of the studies (11/13) were considered of high quality, which we defined as meeting at least 8 of the 11 assessment criteria. Only two reviews scored within the medium-quality range (4–7), and none were in the low-quality range (0–3). All the included studies satisfied the first criteria of stating a clear and explicit research question or aim, appropriateness of inclusion criteria, appropriateness of methods to combine studies and including a recommendation for policy or practice based on reported data. On the other hand, more than half (8/13) of the studies failed to meet the criterion of assessing publication bias. All the studies were included in the synthesis of findings.

3.4. Findings of the review

3.4.1. COVID-19-related mortalities among healthcare workers

Overall, four reviews (Bandyopadhyay et al., 2020; Gómez-Ochoa et al., 2021; Gross et al., 2021; Sahu et al., 2020) reported mortality among healthcare workers (Table 3). Three of the reviews (Bandyopadhyay et al., 2020; Gross et al., 2021; Sahu et al., 2020) have overlapping primary studies (Supplemental Table 1). All the studies were of high quality (Table 2). Among these studies, the estimated death rate ranged from 0.3% (Sahu et al., 2020) to 54.2% (Gross et al., 2021), with the highest death rate associated with the early stages of the outbreak in Hubei Province, in mainland China. A total of 1468 deaths (out of 169,474 infections) was reported in three of the reviews (Bandyopadhyay et al., 2020; Gross et al., 2021; Sahu et al., 2020), which produces an overall case mortality rate of 0.87% (approximately 9 deaths per 1000 infections). Of these, the reviews by Bandyopadhyay et al. (2020) and Sahu et al. (2020) included a primary study conducted in China (Supplemental Table 1) but it is unclear from the review by Bandyopadhyay et al. (2020) if the repeated primary study forms part of the pooled estimate.

Only one review (Bandyopadhyay et al., 2020) reported sociodemographic variables associated with COVID-19 mortality. Overall, the number of deaths was higher among men (70.8%, $n = 550$) compared to women and doctors (51.4%, $n = 525$) compared to other professionals (Bandyopadhyay et al., 2020). The death rate was highest (37.2 deaths reported per 100 infections) among healthcare workers over 70 years of age (Bandyopadhyay et al., 2020). The highest death rate was reported in Europe (712 out of 119,628 infections); however, the Eastern Mediterranean region (159 out of 2779 infections) had the highest Case Fatality Rate: 5.7 deaths per 100 infections (Bandyopadhyay et al., 2020). Limited data have suggested that general practitioners and mental health nurses were at the highest risk of death (Bandyopadhyay et al., 2020).

Two reviews (Bandyopadhyay et al., 2020; Sahu et al., 2020) compared the death rate between healthcare workers and the general population Bandyopadhyay et al. (2020). estimated 0.52% of Healthcare workers death out of the total population of COVID-19 deaths, while Sahu et al. (2020) estimated a 0.3% death rate among healthcare workers compared to 2.3% among all COVID-19 patients.

3.4.2. COVID-19-related infection among healthcare workers

Six reviews (Bandyopadhyay et al., 2020; Gómez-Ochoa et al., 2021; Gross et al., 2021; Lee et al., 2021; Sahu et al., 2020; Shaukat et al., 2020) assessed SARS-CoV-2 infection among healthcare workers (Table 3). Of these, four reviews (Bandyopadhyay et al., 2020; Gómez-Ochoa et al., 2021; Gross et al., 2021; Sahu et al., 2020) have overlapping primary studies (Supplemental Table 1). Five of the six studies were of high quality (Table 2). Four reviews reported 166,138 overall infections among healthcare workers (Bandyopadhyay et al., 2020; Lee et al., 2021; Sahu et al., 2020; Shaukat et al., 2020), ranging between 23 (Lee et al., 2021) and 152,888 (Bandyopadhyay et al., 2020). The infection rate among healthcare workers was estimated to be 14.5% (Lee et al., 2021; Shaukat et al., 2020), while that of healthcare workers among the general population was estimated to be 8.5% (Gross et al., 2021; Sahu et al., 2020).

Regarding the socio-demographics of the respondents, female healthcare workers (71.6%, $n = 14{,}058$) had a higher rate of infection than male healthcare workers (Bandyopadhyay et al., 2020), and a high infection rate was associated with large household size (Gómez-Ochoa et al., 2021). Additionally, the number of cases was highest (4812 out of 14,058) in the 50–59 year age group (Bandyopadhyay et al., 2020). Among the healthcare workers with different roles, nurses had the highest rate of infection, ranging between 38.6% ($n = 10{,}706$; Bandyopadhyay et al., 2020) and 48% (95% CI: 41–56%; Gómez-Ochoa et al., 2021), in comparison to physicians, whose infection rate was 25% (95% CI: 12–36%), and other healthcare workers, among whom the infection rate was 23% (95% CI: 12–36%; Gómez-Ochoa et al., 2021). Working on the front line, in direct contact with COVID-19 patients is sig-

Table 3
COVID-19 mortalities, infection, symptoms, complications, skin injuries, poor sleep quality and work-related stress among healthcare workers.

Outcome	Measure	Reference	Effect of COVID-19 on outcome			Effect size/comment
			Compared		Overall/no comparison	
			Significant	Not significant		
COVID-19 mortalities/ death rate	Estimate	Bandyopadhyay et al. (2020)			√	†0.92% (CFR =0.92 per 100 infections, n = 1413 out of 152,888 infections) as at May 2020. 0.52% deaths out of general population deaths.
	Estimate	Gómez-Ochoa et al. (2021)			√	*0.5% (95%CI: 0.02–1.3), N = 11
	Estimate	Gross et al. (2021)			√	Ranged from 0.7% (n = 23 out of 3387 infections) on 3 April to 54.2% (13 out 24 Healthcare workers) on 16 March 2021, all in China. N = 2
	Estimate	Sahu et al. (2020)	√			0.3% (95%CI:0.2–0.4) N = 2, n = 32 out of 13,199 infections < all patients (2.3%, 95%CI:2.2–2.4) N = 2
COVID-19 infection prevalence /infection rate	Estimate	Bandyopadhyay et al. (2020)			√	†152,888 infections as at May 2020. Highest rate in Europe (78.2%/119,628 cases), & lowest in Africa (1%/1472 cases)
	Estimate	Gómez-Ochoa et al. (2021)			√	31,866 infection, N = 37. 11% (95%CI: 7–15) out of those screened (N = 46, n = 75,859) using reverse transcription–polymerase chain reaction; 7% (95%CI: 4–11) out of n = 27,445 presence of antibodies
	Estimate	Gross et al. (2021)			√	Ranged from 4.4% (n = 3387 out of 77,262 all cases) on 24th February in China to 29.9% (50 out of 167 all cases) on 18th March in USA, N = 6
	Estimate	Lee et al. (2021)			√	8.6% (n = 23 out of 269 Healthcare workers infections). Infection rate due to surgery = 3.92% (39 infection per 995 surgeries conducted)
	Estimate	Sahu et al. (2020)			√	13,199 N = 11, overall infections. 10.1% (95%CI: 5.3–14.9) N = 11, out of all covid patients (n = 119,216). Proportion varied according to country: China 4.2% (95%CI:2.4–6.0, N = 7); USA 17.8% (95%CI:7.5–28, N = 3); Italy 9.0% (95%CI:8.6–9.4, N = 1).
	Estimate	Shaukat et al. (2020)			√	33.7% (n = 28 out of 83 Healthcare workers) N = 1
Complications/ critical conditions	Estimate	Gómez-Ochoa et al. (2021)			√	5% (95%CI: 3–8), N = 8 severe disease
	Estimate	Gross et al. (2021)			√	6%, n = 50, nursing staff
	Estimate	Sahu et al. (2020)	√			9.9%, (95%CI:0.8–18.9) N = 4 < all COVID-19 positive patients (29.4%, 95%CI:18.6–40.2) N = 4.
	Estimate	Shaukat et al. (2020)			√	*30 Healthcare workers with mild-severe manifestation N = 1
Comorbidities	Estimate	Gómez-Ochoa et al. (2021)			√	7% (95% CI: 4, 10) prevalence of hypertension; 3% (95% CI: 1, 8) cardiovascular disease; 4% (95% CI: 2, 7) type 2 diabetes; 3% (95% CI: 1, 6) chronic obstructive pulmonary disease. n = 11,772
Anosmia	Estimate	Gómez-Ochoa et al. (2021)			√	OR = 28.37 (9.45–85.16) N = 4
Chills	Estimate	de Pablo et al. (2020)	√			4.5% (95%CI:2–10) N = 2, n = 118
Chest pain	Estimate	Gómez-Ochoa et al. (2021)			√	8% (95%CI: 1–18) N = 6
	Estimate	Shaukat et al. (2020)			√	*7%, N = 3
Cough	Estimate	de Pablo et al. (2020)			√	56% (95%:40- 72) N = 5, n = 300
	Estimate	Gómez-Ochoa et al. (2021)			√	57% (95% CI: 50–65), N = 29
	estimate	Shaukat Et Al. (2020)			√	*80%, n = 3
diarrhea	estimate	de Pablo et al. (2020)	√			12% (95%ci: 5–25) n = 5, n = 300
	Estimate	Gómez-Ochoa et al. (2021)			√	18% (95%CI: 14–22) N = 21
	estimate	Shaukat et al. (2020)			√	*7%, n = 3
dyspnea	estimate	de Pablo et al. (2020)	√			20% (95%ci: 11–33) n = 5, n = 368
Fatigue	Estimate	de Pablo et al. (2020)			√	38% (95%CI: 15–67) N = 3, n = 142
	Estimate	Gómez-Ochoa et al. (2021)			√	OR = 2.41 (95%CI: 0.92 – 6.27) N = 5
Fever	Estimate	de Pablo et al. (2020)	√			71% (95%CI: 58–82) N = 5, n = 300
	Estimate	Gómez-Ochoa et al. (2021)			√	57% (95% CI: 50, 64) N = 29
	Estimate	Shaukat et al., 2020			√	*85%, N = 3
Headache	Estimate	de Pablo et al. (2020)			√	23% (95%CI: 7–55) N = 4, n = 246
	Estimate	Gross et al. (2021)			√	*81%, N = 1. OR = 3.91 (95% CI: 1.35–11.31) associated with PPE use > 4 h/per day
	Estimate	Shaukat et al. (2020)			√	*7% N = 3
Haemoptysis	Estimate	Shaukat et al. (2020)			√	*7% N = 3
Malaise	Estimate	Gómez-Ochoa et al. (2021)			√	43% (95% CI: 26–61) N = 1
	Estimate	Shaukat et al. (2020)			√	*70%, N = 3
Myalgias	Estimate	de Pablo et al. (2020)			√	17.8% (95%CI: 4–51) N = 4, n = 228
	Estimate	Gómez-Ochoa et al. (2021)			√	48% (95% CI: 35–62) N = 10

(Continued on next page)

Table 3 (*Continued*).

Outcome	Measure	Reference	Effect of COVID-19 on outcome			Effect size/comment
			Compared		Overall/no comparison	
			Significant	Not significant		
Nausea and vomiting	Estimate	de Pablo et al. (2020)	√			7% (95%CI: 0.8–43) $N = 2$, $n = 140$
	Estimate	Gómez-Ochoa et al. (2021)			√	9% (95%CI: 6–14) N = 7
Shortness of breath	Estimate	Gómez-Ochoa et al. (2021)			√	22% (95%CI: 17–28) $N = 21$
Sore throat	Estimate	de Pablo et al. (2020)	√			20.7% (95%CI: 8–44) $N = 3$, $n = 204$
	Estimate	Gómez-Ochoa et al. (2021)			√	OR = 0.55 (95%CI: 0.30 – 1.01). N = 3
Skin injuries due to PPE use	Estimate	Gross et al. (2021)			√	*Ranged from 48.2%–97%. $N = 4$
	Estimate	Shaukat et al. (2020)			√	*97% skin damage; 83.1% Nasal bridge affected; 70.3% skin dryness or tightness and desquamation $N = 1$
Poor sleep quality	PSQI	Al Maqbali et al. (2020)			√	41% (95% CI 22–64), $N = 5$. Assessed among nurses
	PSQI	Krishnamoorthy et al. (2020)			√	43% (28%–59%) $N = 5$ higher than general population 34% (12%–60%) but less than covid patients 82% (66%–92%).
Work-related stress	ASDI, SCL-90, IES-R; PSS, SOS, SRQ	‡Al Maqbali et al. (2020)			√	43% (95% CI: 37–49), $N = 40$, nurses.
	NA	‡Krishnamoorthy et al. (2020)			√	33% (19%–50%) $N = 5$ less than general population 36% (5%–75%)
	NA	‡Kunz et al. (2021)			√	40% $N = 1$. Only highest prevalence reported (Spain).
	IES-R, DASS-21, PSS	‡Mahmud et al. (2021)			√	44.86% (95% CI: 36.98–52.74) $N = 41$, $n = 82{,}783$.
	NA	‡Moitra et al. (2021)			√	*Not quantified. $N = 13$
	NA	‡Varghese et al. (2021)			√	40.6% (95% CI = 25.4%–56.8%,) $N = 10$, $n = 4204$

† Value was estimated from both research and report sources with unclear N;
* total number of participants is unclear;
‡ combined physical and mental stress; ASDI: Acute Stress Disorder Inventory; CFR: Case Fatality Rate; DASS-21: Depression, Anxiety Stress Scale; DFE: Doctors Fears and Expectations; IES-R Impact of Event Scale-Revised; NA: Not Available; OR: Odds Ratio; PPE: Personal Protective Equipment; PSQI Pittsburgh Sleep Quality Index; PSS Perceived Stress Scale; SOS: Stress Overload Scale; SRQ: Self Reporting Questionnaire.

nificantly associated with a higher infection rate (Gómez-Ochoa et al., 2021; Shaukat et al., 2020). However, those working in non-frontline wards reported a higher rate of infection (72.2%) than those in frontline wards (3.7%) in China (Gross et al., 2021). Additionally, high infection rates were associated with working in operating rooms/surgeries (24%; 95% CI: 17–31%; Gómez-Ochoa et al., 2021) and working in non-emergency units during screening (43%–72.2%; Gómez-Ochoa et al., 2021; Gross et al., 2021).

The most significant risk factor for SARS-CoV-2 infection among healthcare workers was using a regular medical mask instead of an N95 respirator (OR = 464.82, 95% CI: 97.73-infinite; Gómez-Ochoa et al., 2021). Furthermore, unqualified handwashing reported from the same primary study data by three reviews (OR = 2.64, 95% CI: 1.04–6.71; Gómez-Ochoa et al., 2021; Gross et al., 2021; Shaukat et al., 2020), suboptimal hand hygiene before/after patient contact (OR = 2.43 to 3.10; Gómez-Ochoa et al., 2021; Gross et al., 2021; Shaukat et al., 2020), improper use of personal protective equipment (OR = 2.82, 95% CI: 1.11–7.18; Gómez-Ochoa et al., 2021; Gross et al., 2021; Shaukat et al., 2020), close contact with patients (12 times/day) and long days working contact hours ($\geq$ 15 h; Shaukat et al., 2020) were risk factors for SARS-CoV-2 infection. The infection rate among healthcare workers also increased if they had a family member diagnosed with COVID-19 (relative risk [RR] = 2.76, 95% CI: 2.02–3.77; Shaukat et al., 2020). Additionally, lack of personal protective equipment was reported as a concern among frontline health workers (Gómez-Ochoa et al., 2021; Gross et al., 2021). Healthcare workers who never used personal protective equipment were approximately four times more likely to be infected compared with those with proper protection (OR = 3.72, 95% CI: 2.12–6.52; Gómez-Ochoa et al., 2021). The prevalence of infection was higher among symptomatic healthcare workers (19%, 95% CI: 12–28%) than among asymptomatic healthcare workers (5%, 95% CI: 1–13%; Gómez-Ochoa et al., 2021).

Two reviews (Bandyopadhyay et al., 2020; Sahu et al., 2020) compared cases across countries and regions Bandyopadhyay et al. (2020). reported that the highest rate was in Europe (78.2%, $n = 152{,}888$), while the lowest rate was in Africa (1%, $n = 152{,}888$). In contrast, Sahu et al. (2020) reported that the highest infection rate was in the USA (17.8%, 95% CI: 7.5–28%, $N = 3$), compared to Italy's 9.0% (95% CI: 8.6–9.4%, $N = 1$) and China's 4.2% (95% CI: 2.4–6.0%, $N = 7$).

3.4.3. COVID-19-related clinical symptoms among healthcare workers

Three reviews (de Pablo et al., 2020; Gómez-Ochoa et al., 2021; Shaukat et al., 2020) reported various clinical symptoms associated with COVID-19, including anosmia, chills, chest pain, cough, diarrhea, dyspnea, fatigue, fever, headache, haemoptysis, malaise, myalgias, nausea/vomiting, shortness of breath and sore throat (Table 3). Of these, the reviews by de Pablo et al. (2020) and Gómez-Ochoa et al. (2021) repeated one primary study conducted in China (Supplemental Table 1). Two of the three studies were of high quality (Table 2).

The reported prevalence of the SARS-CoV-2 infection symptoms were: chills (4.5%), cough (56%–80%), diarrhea (7%–18%), dyspnea (20%), fatigue (38%), fever (57%–85%), headache (7%–81%), haemoptysis (7%), malaise (43%–70%), myalgias (17.8%–48%), nausea/vomiting (7%–9%), shortness of breath (22%) and sore throat (20.7%). However, the most significant symptom associated with COVID-19 infection was anosmia, with an odds ratio (OR) of 28.37 (95% CI: 9.45–85.16) compared to fever (OR = 4.46), myalgia (OR = 3.06), fatigue (OR = 2.41) and sore throat (OR = 0.55; Gómez-Ochoa et al., 2021).

3.4.4. COVID-19-related complications and comorbidities among healthcare workers

Four reviews (Gómez-Ochoa et al., 2021; Gross et al., 2021; Sahu et al., 2020; Shaukat et al., 2020) assessed the overall prevalence of complications associated with COVID-19, which ranged from 5% to 9.9% (Table 3). Three of the four studies were of high quality (Table 2). Of these, the reviews by Gross et al. (2021) and Shaukat et al. (2020) repeated one primary study (Supplemental Table 1), while the reviews by de Pablo et al. (2020) and Gómez-Ochoa et al. (2021) repeated another primary study (Supplemental Table 1) Sahu et al. (2020). compared the rate of complications among healthcare workers to that among the general population and reported an approximately threefold higher rate among the general population (9.9% vs 29.4%).

Related comorbidities were reported in one review (Gómez-Ochoa et al., 2021), which indicated a 7% (95% CI: 4–10%) prevalence of hypertension and a prevalence of 3% (95% CI: 1–8%) for cardiovascular disease, 4% (95% CI: 2–7%) for type 2 diabetes and 3% (95% CI: 1–6%) for chronic obstructive pulmonary disease.

3.4.5. Poor sleep quality

Only two systematic reviews (Al Maqbali et al., 2020; Krishnamoorthy et al., 2020) assessed the prevalence of poor sleep quality among healthcare workers, reporting a prevalence of 41–43% (Table 3). Both studies were of high quality (Table 2) and repeated four primary studies (Supplemental Table 1).

Krishnamoorthy et al. (2020) indicated a higher prevalence of poor sleep quality among healthcare workers (43%) compared to the general population (34%), but a lower prevalence compared to COVID-19 patients (82%) Al Maqbali et al. (2020), on the other hand, reported frontline nurses' prevalence of sleep disturbance to be 47% (95% CI: 34–60.1%), higher than that of other non-frontline nurses, at 37% (95% CI: 28–46%).

3.4.6. Skin injuries/allergies

Only two reviews (Gross et al., 2021; Shaukat et al., 2020) reported skin-related problems, all of which were associated with prolonged use of personal protective equipment (Table 3). The two reviews repeated one primary study (Supplemental Table 1) and one of the two studies was of high quality (Table 2). Both reviews reported data from the same primary study, which indicate wearing N95 respirators for a period longer than 6 h doubled the risk of facial skin lesions (OR 2.02; 95% CI: 1.35–3.01; Gross et al., 2021; Shaukat et al., 2020). Moreover, frequent hand hygiene (> 10 times per day) increased the risk of skin damage, as reported from data by the same primary study (OR 2.17; 95% CI: 1.38–3.43; Gross et al., 2021; Shaukat et al., 2020). Additionally, moisture-related skin issues, as well as skin tears, were associated with the use of personal protective equipment (Gross et al., 2021).

3.4.7. Work-related stress

Six reviews (Al Maqbali et al., 2020; Krishnamoorthy et al., 2020; Kunz et al., 2021; Mahmud et al., 2021; Moitra et al., 2021; Varghese et al., 2021) reported stress associated with workload/long working hours coupled with psychological distress among healthcare workers (Table 3), all of which have overlapping primary studies (Supplemental Table 1). Five of the six reviews were of high quality (Table 2). The prevalence of stress ranged from 33% to 44.86% in five of the six reviews; one review did not quantify the prevalence of stress (Table 3).

Stress associated with work was higher among female healthcare workers (Moitra et al., 2021; Varghese et al., 2021), those who were married (Varghese et al., 2021), those who had at least one child (Varghese et al., 2021), nurses (Varghese et al., 2021), trainees (Varghese et al., 2021) and non-physicians (Moitra et al., 2021). Additionally, burnout associated with workload was reported to be different among physicians with different roles, with resident physicians experiencing greater burnout than attending physicians (Moitra et al., 2021). Concerning work duration, permanent workers reported greater burnout and fatigue compared to temporary workers (Moitra et al., 2021) Varghese et al. (2021). also reported that stress was associated not only with a heavy workload and long working hours but also with work intensity and patient load.

3.4.8. Physical health preventive measures

Of the 13 systematic reviews included, only 2 reported preventive measures along with the COVID-19-related physical health issues (Gross et al., 2021; Shaukat et al., 2020). Effective use of personal protective equipment was identified as a measure protecting against SARS-CoV-2 infection among healthcare workers (Gross et al., 2021). Routine laboratory testing and clinical diagnosis were also associated with reducing the infection rate (Gross et al., 2021). Additionally, testing and targeted self-isolation of healthcare workers in addition to improved hygienic measures and use of surgical face masks were reported to have the potential to reduce the spread of the infection (Gross et al., 2021). Two reviews that used the same primary study data reported the potential for use of surgical masks compared to no mask to prevent COVID-19 infection (Gross et al., 2021; Shaukat et al., 2020).

4. Discussion

This umbrella review assessed various aspects of the physical health of healthcare workers during the COVID-19 pandemic. To our knowledge, this is the first review to collectively examine COVID-19-related mortality, infection, clinical symptoms, complications, comorbidities, skin injuries, poor sleep quality and work-related stress among nurses, medical doctors, dental professionals, physiotherapists, and other healthcare professionals. The review has a major strength of providing comprehensive support from the available evidence about the physical impact of COVID-19 on healthcare professionals, who are at the forefront of managing the pandemic.

A key finding from this review indicates an estimated mortality rate of 9 deaths per 1000 infected healthcare workers, which warrants urgent intervention in the form of effective protective measures, early diagnosis and prompt treatment. At the initial stage of the pandemic, the death rate among healthcare workers was as high as 54.2% in Hubei Province, in mainland China, where the outbreak originated. This may have been associated with poor knowledge of how to handle the virus, coupled with poor awareness among the healthcare population to effectively use preventive measures. The number of COVID-19 deaths among healthcare workers continues to surge (David et al., 2021), particularly in resource-poor settings, despite the effort to control the outbreak. Despite an increase in trends of COVID-19 cases across the globe, there is a reported decrease in mortality rates in many countries. For instance, a retrospective cohort study from England shows about a two-fold decrease in the relative probability of COVID-19 death in April 2021 compared to October 2020, particularly among those over the age of 70 years (Beaney et al., 2021). This is an indication that as more information is learned about the pandemic, the approach to containing the virus improves, including the use of preventive measures (Haegdorens et al., 2022), early detection/treatment of both symptomatic and asymptomatic persons (Gandhi et al., 2020) as well as the use of vaccinations (Mehrotra et al., 2021). A similar pattern of death among healthcare workers was found during the recent MERS-CoV outbreak, which was associated with high mortality rates, particularly at the initial stage of the outbreak (Bleibtreu et al., 2020). Regarding socio-demographic characteristics, the highest death rate among healthcare workers was observed in the oldest age group

(>70 years) compared to younger age groups. This may relate to the generally high prevalence of comorbidities and weaker immune systems in older adults (Dorshkind et al., 2009; Mahmoud et al., 2021), in addition to the rapid systemic spread of SARS-CoV-2 (Vinayachandran and Balasubramanian, 2020).

The pattern of infection identified in this review indicated a higher number of infected healthcare workers in hard-affected countries like those in Europe and America. Additionally, an estimated infection rate of 14.5% and 8.5% within the healthcare workers' population and within the general population, respectively were found. Based on the findings of the current review, female healthcare workers and nurses were found to be more affected. Higher infection rates among nursing personnel may be associated with the nature of nursing responsibilities, including 24 hour care of infected patients. Additionally, nurses are the healthcare workers mostly involved in the screening of patients and hence are exposed to SARS-CoV-2 before a diagnosis is confirmed in patients (Huang et al., 2020). Additionally, the geographic location of an healthcare worker serves as a determinant of SARS-CoV-2 infection. It was identified in the current review that the rate of infection was highest in the Hubei province of mainland China at the initial stage of the outbreak. As the outbreak progressed, European countries and the Americas reported a higher number of infected healthcare workers. Surprisingly, the lowest infection rate was reported in Africa (1%), despite the poor healthcare structure in many African countries (Akinnagbe et al., 2018; Aliyu et al., 2020). Although the reason for the low number of cases of COVID-19 in Africa remains largely unclear, evidence suggests poor reporting and limited testing capacity in many low-middle income countries (Walker et al., 2020), which may contribute to the low reported number of infections. Further evidence suggests that prevailing comorbidities like malaria, chronic malnutrition, HIV and TB may have played a role in the dynamics of COVID-19 pandemic in Africa, hence the need for further investigation (Anjorin et al., 2021). Additionally, limited evidence from west Africa suggests a practice of self-medication including traditional medicines to prevent COVID-19 infection may be associated with the COVID-19 cases (Chinenye-Julius et al., 2021).

Identification of clinical symptoms of SARS-CoV-2 infection is important for early diagnosis and treatment. COVID-19, being an infectious disease, is characterized by cardinal signs of infection, particularly fever (Zens et al., 2020). This is supported by the findings of the current review, which shows that fever (85%) is one of the most common symptoms, along with headache (85%), cough (80%) and malaise (70%), while nausea/vomiting (9%) was the least occurring symptom. While our review has limited data to support which of these symptoms come sooner or later, existing literature indicates cough as the most likely symptom during the early or late stages of the infection (Pullen et al., 2020). Conversely, fever, dyspnea, headache and fatigue were the most occurring symptoms associated with a mid-infection stage (Pullen et al., 2020). However, none of the onsets of the aforementioned symptoms was significantly different except for fatigue, which was higher at the mid-infection stage compared to the late-infection stage (Pullen et al., 2020). These necessitate consideration of clinical symptoms as indications of COVID-19 infection. Accordingly, this review found that the prevalence of infection among symptomatic healthcare workers (19%, 95% CI: 12–28%) was higher than among asymptomatic healthcare workers (5%, 95% CI: 1–13%). This is an indication that consideration of both symptoms and non-symptoms in the screening criteria for testing may improve the identification of SARS-CoV-2-positive individuals and prevent further transmission. The review also found limited evidence supporting the identification of COVID-19 cases, of which using reverse transcription-polymerase chain reaction yielded higher positive cases (11%) compared to detection of antibodies present (7%). Another consideration is the possibility of false-positive COVID-19 cases due to the rapid approach toward controlling the pandemic, which has significant consequences at health systems, personal or societal levels (Surkova et al., 2020). While only 5% of asymptomatic healthcare workers were found positive for COVID-19 infection, and considering the possibilities of false-positive among these 5%, the cost and benefit of asymptomatic testing should be considered based on the country's healthcare system as well as the availability of both human and material resources.

While identification of clinical symptoms may be an indicator of infection, prior lifestyles and/or comorbidities could promote the development of infectious diseases like COVID-19. One study (Gómez-Ochoa et al., 2021) from the findings of this review reported comorbidities, with hypertension and type 2 diabetes as the most common comorbidities among healthcare workers, no associations with lifestyles were reported. Generally, lifestyles particularly regular exercise and healthy eating were found to promote wellbeing and improve immunity (Ranasinghe et al., 2020). Conversely, pre-existing comorbidities including cardiovascular diseases, prediabetes/diabetes, cancer, autoimmune diseases (Carey et al., 2018; Cowan et al., 2021; Colón-López et al., 2018; Kuang et al., 2020) as well as prior use of immunosuppressant medications (Singh et al., 2020) were associated with increased risk of infection. Additionally, non-communicable diseases were long associated with poor lifestyles like unhealthy diet (Christ and Latz, 2019), while recent evidence linked communicable diseases such as COVID-19 with poor lifestyles (Ranasinghe et al., 2020; Zhou et al., 2021). Accordingly, obesity was identified as a high-risk factor for severe coronavirus diseases (Zhou et al., 2021), while regular exercise was associated with wellbeing (Ranasinghe et al., 2020) during COVID-19. These are indications that promoting healthy lifestyles, use of preventive measures and effective treatment of underlying conditions may be beneficial in containing infectious diseases like COVID-19.

The importance of using personal protective equipment as a protective measure among healthcare workers was demonstrated in this review. The use of a regular medical mask compared to a properly fitted N95 mask was associated with the highest risk of infection among healthcare workers, with an OR of over 400 (OR = 464.82, 95% CI: 97.73-infinite). This highlights the need for effective personal protective equipment use during epidemics of infectious diseases like COVID-19. Given that the nature of SARS-CoV-2 transmission includes direct contact, aerosols and droplets, training about the usage and effective use of personal protective equipment has been recommended, particularly among primary healthcare providers (Haegdorens et al., 2022; Khunti et al., 2020). Accordingly, evidence has shown the improved effectiveness of properly fitted N95 masks in terms of filtration efficiency in comparison to other non-standard masks during the COVID-19 pandemic (Dugdale and Walensky, 2020). Additionally, this review found that SARS-CoV-2 infection was higher among healthcare workers involved in screening in non-emergency wards. This may relate to the fact that these healthcare workers may be unaware that a person is infected until after the test is conducted. Although screening was one of the recommended measures for epidemiologic identification of cases during previous epidemics (Al-Taufiq et al., 2014; Chutiyami and Salihu, 2016), the current findings indicate the high potential of exposing healthcare workers to infection during the COVID-19 pandemic. It is important to note that prolonged use of personal protective equipment may lead to skin injuries, as identified in this review; hence, there is a need for shorter working hours among frontline health professionals.

Sleep deprivation and occupational stress are two different, but interrelated findings identified in this review. Approximately 40% of healthcare workers each experienced poor sleep quality and high work-related stress during the pandemic, which may lead to psychological distress. Healthcare workers are undergoing longer working hours and heavy workloads due to the high demand on frontline care staff to conduct screening, isolation, and routine care of infected and at-risk patients. Sleep is generally associated with minimized physical activity, quality of life and personality (Leger and Bayon, 2010; Wu and Wei, 2020; Yazdi et al., 2014). The high demand for healthcare workers to work during health crises is known to contribute to sleep disturbances (Wu and Wei, 2020). To complicate things, these healthcare workers face a greater risk of contracting the virus, which further exposes their family members and hence adds to the psychological burden on health professionals (De Kock et al., 2021; Gohil et al., 2021). The impact of these fears and stress has the potential to not only affect the mental health of the professionals, but their physiological function and recovery during the pandemic (Karnatovskaia et al., 2020). Additionally, sleep disturbance is associated with a variety of physical complications, including increased risk of obesity, diabetes, high blood pressure, increased heart rate, heart attack and stroke (Silva-Costa et al., 2015). Conversely, good sleep quality can swiftly improve the body's function, relieve work-related fatigue, preserve energy levels, and maintain psychological health (Wu and Wei, 2020).

4.1. Limitations of the review

While this systematic review provides comprehensive support from the available evidence regarding COVID-19-related mortality and different aspects of physical health among healthcare professionals, various limitations must also be considered when interpreting these findings.

Considering all the included studies were published in 2020 and 2021, we noted a repetition of primary studies in the included systematic reviews. Specifically, out of the 1230 primary studies/reports, there were 493 published research papers, of which 55 were repeated (supplemental Table 1). The remaining 737 were non-research papers (including government reports and media articles), out of which no clear repetition was noted. Of the non-research papers, the review by Bandyopadhyay et al. (2020) accounted for 79% (580), which examined mortality and infections. To minimize this error, we considered the repetition, where such information is made clear. Additionally, findings were reported as a range before an overall estimate is given where applicable. Finally, the repeated studies were identified across all the included systematic reviews and reported as supplemental information for readers' reference.

Many reviews (Table 3) did not provide the exact number of participants used to estimate particular findings; as a result, the specificity of such findings cannot be ascertained. We also excluded one review at full-text screening based on no English full-text was available. Additionally, the fact that some included reviews have the general population as participants in addition to healthcare professionals, the age of the participants ranged from 15 to 84 years, indicating the inclusion of younger and older age groups that may not be comparable to healthcare professionals age groups. However, our findings only refer to the professionals.

The quality assessment in the current review revealed that the majority of the included systematic reviews (8/13) did not meet the JBI criterion of assessing publication bias. This might be associated with the COVID-19 period and the urgency to include all available evidence irrespective of the risk of bias. Moreover, quality assessment of the studies included in the current review revealed that most of the studies (11/13) were of high quality based on the JBI checklist for systematic reviews (Table 2).

Additionally, systematic reviews both with and without meta-analyses were included in this review; therefore, no further meta-analyses were conducted. Instead, the findings were narratively synthesized; the only effect sizes available are those reported by the included studies coupled with most of the studies did not report country-specific data. Furthermore, it is unclear from the included systematic reviews whether the healthcare workers had underlying medical conditions prior to the COVID-19 pandemic that may have exacerbated the development of the various health issues during the pandemic. Finally, the current review only found one of the thirteen reviews (Gómez-Ochoa et al., 2021) that reported comorbidities, while the preventive measures reported were those identified alongside the physical health issues. Additional research remains necessary to specifically investigate comorbidities/prior lifestyles associated with coronavirus infection as well as interventional techniques capable of protecting healthcare workers from SARS-CoV-2 infection and its associated consequences.

4.2. Conclusion

Based on the findings of this umbrella review, we concluded that healthcare workers experienced a high burden of the COVID-19 pandemic, including mortality and various physical health issues. Nurses remain the most affected group of healthcare professionals, with the majority of infections being contracted during the screening of patients (findings of high quality). Hypertension was the most common comorbidity (high quality), while cough, fever, headache, and malaise were the major clinical symptoms experienced by the healthcare workers (high and medium quality); hence, these should be considered as standard pre-screening indicators. Occupational stress (high and medium quality) and poor sleep quality (high quality) were very prevalent among healthcare workers. This review, therefore, recommends targeted health policies at the facility and state/county levels and interventions that address specific health issues of health professionals worldwide during the COVID-19 pandemic.

These findings have significant implications for nursing and healthcare systems at large. While healthcare workers remain critical in the management of the pandemic, their health and that of their families remain a priority. This necessitates the provision of adequate personal protective measures to be used by both the professionals and service users. Early laboratory testing and prompt treatment of SARS-CoV-2-positive healthcare workers are imperative to minimize further spread. Evidence suggests that even vaccinated people can carry and/or transmit infection (Griffin, 2021), it is therefore important for health systems to consider testing vaccinated healthcare professionals periodically, particularly frontline workers. Further, motivating healthcare workers using measures such as a supportive working environment was demonstrated to reduce hesitation to work during the pandemic (Cobilinschi et al., 2021; Malesza, 2021), therefore health systems and management need to minimize long working hours and frequently rotate healthcare workers, particularly nurses, to safeguard their well-being. Integrated institutional support also has the potential to promote positive work culture among healthcare workers (Krystal et al., 2021). Therefore, continuous psychological support in addition to the physical preventive measures remains necessary to increase morale and enthusiasm among professionals so that they can continue to provide healthcare services and achieve the goal of successfully containing the virus.

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Supplementary materials

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