Systematic Review

Infection and death in healthcare workers due to COVID-19: a systematic review

Infecção e óbitos de profissionais da saúde por COVID-19: revisão sistemática

Infección y muerte de profesionales de la salud por COVID-19: revisión sistemática

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Abstract

Objective: To identify evidences regarding infection by SARS-CoV-2 and deaths of healthcare workers and related-risk factors.

Methods: We conducted a systematic review by searching the following databases SCOPUS, VHL Regional Portal, PubMed and Embase. We included studies on infection and death of healthcare workers who delivery care for COVID-19 patients. There were no restriction on date of publication, idiom, or type of study. The search was conducted until April 14, 2020.

Results: A total of 28 articles were selected. Most mentioned risk factors were: scarcity, inadequate use or non-usage of personal protective equipment, work overload, close contact with potentially infected patients and/or coworkers, risk for aerosol-generating procedures, late diagnosis and inadequate air renovation. According to each country, the number of infected workers ranged from 1,716 to 17,306. Concerning deaths, there are data of up to 605 healthcare workers who died of COVID-19 all over the world. Evidences found were editorials, cross-sectional, and cohort studies.

Conclusion: Studies identified showed high number of infection and deaths among healthcare workers. Overload of health system was a significant factor.

Resumo

Objetivo: Identificar as evidências quanto à infecção pelo SARS-CoV-2 e óbitos dos profissionais de saúde e fatores de risco relacionados.

Métodos: Realizou-se uma revisão sistemática buscando-se artigos nas bases de dados Scopus, Portal Regional da BVS, Pubmed e Embase, relacionados à infecção e óbito de profissionais da saúde envolvidos no tratamento de pacientes com a COVID-19. Não houve restrição quanto a data de publicação, idioma ou tipo de estudo. Para a busca foi considerado publicações até 14 de abril de 2020.

Resultados: Foram incluídos 28 artigos. Os fatores de risco mais citados foram: escassez, uso inadequado ou não uso de equipamentos de proteção individual, sobrecarga de trabalho, contato próximo com pacientes e/ou colegas de trabalho potencialmente contaminados, procedimento com risco de geração de aerossol, diagnóstico tardio e renovação de ar ambiente inadequado. De acordo com cada país, o número de profissionais infectados variou de 1.716 a 17.306. Quanto aos óbitos, existem dados de até 605 profissionais falecidos no mundo inteiro. As evidências encontradas são editoriais, estudos transversais e de coorte.

Conclusão: As evidências identificadas demonstram um alto número de profissionais infectados e que foram a óbito, sendo a sobrecarga do sistema de saúde um fator significativo.

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Resumen

Objetivo: Identificar evidencias sobre la infección por SARS-CoV-2 y muerte de profesionales de la salud y factores de riesgo relacionados.

Métodos: Se realizó una revisión sistemática en busca de artículos en las bases de datos Scopus, Portal Regional de la BVS, Pubmed y Embase, relacionados con la infección y muerte de profesionales de la salud involucrados en el tratamiento de pacientes con COVID-19. No hubo restricción respecto a la fecha de publicación, idioma ni tipo de estudio. Para la búsqueda se consideraron publicaciones hasta el 14 de abril de 2020.

Resultados: Se incluyeron 28 artículos. Los factores de riesgo más mencionados fueron: escasez, uso inadecuado o falta de uso de equipos de protección individual; sobrecarga de trabajo; contacto cercano con pacientes o compañeros de trabajo potencialmente contaminados; procedimientos con riesgo generador de aerosoles; diagnóstico tardío y renovación inadecuada del aire interior. El número de profesionales infectados varió de 1.716 a 17.306, de acuerdo con cada país. Respecto a las muertes, hay datos de 605 profesionales fallecidos en todo el mundo. La evidencia se encontró en editoriales, estudios transversales y de cohorte.

Conclusión: Las evidencias identificadas demuestran un alto número de profesionales infectados y fallecidos, y la sobrecarga del sistema de salud es un factor significativo.

Introduction

The novel coronavirus disease-2019 (COVID-19) with development of severe acute respiratory syndrome due to SARS-CoV-2/2019-nCoV has caused severe public health and economic problems.[1] In the end of 2019, the virus emerged in the city of Wuhan, Hubei, China characterized by an outbreak of acute respiratory failure among individuals affected by a novel coronavirus. Within the first 5 days, the virus killed 800 people and infected another 70,000.[2,3] Subsequently, the virus had spread rapidly worldwide. The World Health Organization (WHO) declared the situation as a Public Health Emergency of International Concern (PHEIC) in January 30, 2020 and as a pandemic in March 11, 2020.[4]

In April 04, 2020, the Coronavirus Datacenter of John Hopkins Hospital reported 1,181.825 confirmed new cases worldwide, 63,902 deaths, and 244,246 recoveries.[4] In Brazil on February 3, 2020, the Ministry of Health (MH) declared COVID-19 as a Public Health Emergency of National Concern (PHENC) in the ordinance MS n° 188, decree order n° 7,616, November 17, 2020.[5,6]

COVID-19 pandemic has putting healthcare workers (HCW) under pressure with highly potential to affect their physical and mental health.[7] The working environmental represents for HCWs a highly risky factor, given that generalized infection of hospital environments has been related to hospitalization of both symptomatic and asymptomatic infected patients by SARS-CoV-2.[8,9] Ong et. al 2020, identified that viral RNA was detected on many surfaces in a room, such as light switch, doors, windows, and sink after the stay of a symptomatic COVID-19 patient.[8] Other study conducted in laboratorial settings showed that viable SARS-CoV-2 was more stable than other respiratory viruses when artificial aerosolized.[10]

Organized conditions and convenient technological working tools are key for HCWs to be able to perform their work activities safely. A designated team for suspected cases of COVID-19 management is recommended to reduce cross-infection between patients and HCWs.[11] A study conducted in Singapura that followed-up the care environmental during the hospitalization of a children aged 6 months who had tested positive for SARS-CoV-2, but had no respiratory symptoms, and who were keep in isolation after their parents admission due to SARS-COV-2, showed a contaminated environmental even within a 1 square meter area. This contamination was probably spread by HCWs who had contact with the child, therefore, a situation that reinforces the importance of hand hygiene.[9]

According to data reported by the China's National Health Commission, more than 3,300 HCWs were infected in that country, and in Italy this number reached 20% of the country healthcare workers.[12] Most reported occupational risks are exposition to infected environmental, physical and mental exhaustion due to the scarcity of protective personal equipment (PPE), and loss of a patient.[7,12,13] To reduce these risks and infections there are instructions to promote the use of PPEs, practice of hand hygiene, support for psychological needs, and improve of logistics of medical supplies.[14] This study

sought to systematize evidences related with infections and death of healthcare workers associated with risk factors to COVID-19. This review question was: What evidences are available on infections, deaths, and risk factors for healthcare workers (HWC) involved in management of COVID-19 patients?

Methods

This was systematic review with study protocol registered at Open Science (https://osf.io/). The primary goal was to determine related risk to infection and deaths of HCWs during the COVID-19 pandemic. Inclusion criteria were studies related to infection and deaths of HCWs involved in management of COVID-19 patients. There we not restriction concerning date of publication, idiom and type of the study. To collect data concerning deaths of HCW, we also considered newsletters and technical documents.

Search strategy

To identify in published literature up to April 14, 2020, we used individual search strategies in the following electronic database: SCOPUS, VHL Regional Portal, PubMed and Embase (Appendix 1). Full-text of articles with to be selected were retrieved manually.

Study selection

Studies identified by searchers conducted in the selected databases were imported into the Covidence online software. Two independent reviewers conducted the study selection based on title and abstract and, after that, based on full-text of the article. In case of disagreement between two reviewers, consensus will be obtained through discussion; if consensus cannot be reached, a third reviewer will be consulted. Duplicated articles were identified and excluded from the Covidence online software.

Data extraction and synthesis

For each article, we extracted country and city where the study was conducted or institution affiliation of the first author, study design, infection-related data, deaths of healthcare workers, and risk factors associated with virus transmissibility. Data of articles were extracted and entered in a table using Microsoft Excel® 2016.

Results

We identified 605 studies. Of these, 173 were duplicated. We evaluated title and abstracts of 432 studies, being 367 excluded and 65 included in the full-text analysis. The final sample was composed of 28 articles. The reason for exclusions was the non-response to the question of this review. Disagreements were resolved by discussion between the two reviewers. The PRISMA flowchart[15] describes studies selection and exclusion process (Appendix 2).

All selected studies (28) were published in 2020. Countries where studies were conducted were: China (n=14), the United States (n=3), Italy (n=3), Australia (n=1), United Kingdom (n=1), Singapore (n=3), Sweden (n=1), and Thailand (n=2). Studies type were retrospective (n=2), case report (n=1), cohort study (n=1), editorial, letter to the editor and commentary (n=16), cross-sectional study (n=1), evidence-based recommendation (n=1), timeline report (n=1) and epidemiological data and policies (n=5).

Risk factors for infection with SARS-CoV-2

The most reported infection-related risk factors for SARS-Cov-2 were: scarcity of personal protective equipment (PPE) (n=6), work overload (n=2), inadequate use or non-usage of PPE and poor hand hygiene (n=2), close contact with potentially infected patients/coworkers (n=1), risk for aerosol-generating procedures – AGP (n=1), late diagnosis of COVID-19 (n=1), and inadequate air renovation in negative pressure room (n=1) (Table 1).

Chu et al 2020 reported on work load that among 54 hospitalized physicians diagnosed with COVID-19 from January to February 2020, 39 worked on clinical units (72.2%) 10 in medicine technology department (18.5%), 2 in the emergen-

Table 1. Risk factors associated with transmission

Risk factor	n(%)
Scarcity of PPE	6(42.5)
Cross-infection	1(7.1)
AGP	1(7.1)
Work load	2(14.2)
Late diagnosis of COVID-19	1(7.1)
Inadequate PPE and hand hygiene	2(14.2)
Air exchange – "negative pressure"	1(7.1)
Total	14(100)

AGP – Aerosol-Generating Procedures; PPE – Personal Protective Equipment

cy department (3.7%), and 3 in other non-specified departments/units (5.6%).[16] However, in the study by Koh 2020, of 40 cases among health workers, 31 worked on general wards (77.5%), 7 in the emergency department (17.5%) and 2 in intensive care unit – ICU (5%)[17] (Chart 1).

Chart 1. Overview of high-infection areas (health units)

Author Year Country	Profession	n(%)	Area
Chu et al, 2020 China	Physicians	n=2/54 (3.7%)	Emergency department
		n=39/54 (72.2%)	Other clinics
		n=10/54 (18.5%)	Medicine technology department
		n=3/54 (5.6%)	Non-specified departments/units
Koh, 2020 China	Healthcare workers	31 (77.5%)	General ward
		7 (17.5%)	Emergency unit
		2 (5%)	Intensive Care Unit

Ng et al 2020 evaluated infection of HCW who used face mask (N-95 or surgical) during procedures with aerosol-generating procedures. Of these, 85% were exposed to procedures were protected with masks and they did not become infected. The study suggested that the use of masks, hand hygiene and other standard procedures can protect workers. N-95 masks or equivalent are more recommended by the majority of specialists in aerosol-generating procedures.[18]

Heinzerling et al 2020 evaluated three HCW that developed infection after unprotected exposition to the first case of COVID-19 in a community in the United States. Of note is that these exposition were longer and probably occurred during treatment with nebulizer devices.[19]

Infection of healthcare workers by COVID-19

Epidemiological devices related to infection of HCWs varied in terms of context, presenting a relation particularly with lacking of PPE at times in overload health systems.[20]

In the beginning of outbreak in China, protocols of protection were inconsistent and infection of HCW ranged between 3.5% to 29% in hospitals in Wuhan.[21] During the holidays in the Chinese new year, up to February 11, 2020, a total of 1,716 cases were confirmed among HCW, at a time in which protective measures were already demanded from professionals.[20] Among 2,055 infected HCWs in China up to February 20, 2020, 88% (1,809) were in Hubei.[22] In February 24, the National Health Commission of the People's Republic of China have reported 3,387 cases among HCW, which corresponded to 4.4% of 77,262 cases of COVID-19.[23]

After this period, with enough protective measures and adequate training for HCW, there were no report of infection among 42,600 HCW from Chinese provinces that were providing healthcare in Wuhan until March 31, 2020.[24] Of note is that according to Tysome and Bhutta 2020,[25] 14.8% of cases in HCW were severe. However, according to Chu et al 2020, in 43 of 54 hospitalized HCW for COVID-19 the severity was 79.6%[16] (Chart 2).

In many countries, the infection of HCW is severe, specially by scarcity of PPE considered the overload of health system. In Italy, 17,306 HCW had been infected from a total of 162,004 cases of COVID-19 registered up to April 16, 2020 (10.7%) in the country.[26] In Spain, more than 5,400 HCW were infected until the end of March 2020, almost 14% of total of infection in the whole country.[27] This situation also occurred in the United Sates. According to report of the Centers for Disease Control and Prevention (CDC), among 49,370 cases that information about the person be or not a HCW (15.6% total of 315,531 cases of COVID-19 in the USA from February 12 to April 9, 2020), 9,282 were HCW (19%).[28] In Australia in April 11, 2020, a time with lower register of overload of health system, there were reports of 159 cases among HCW in the state of Vitoria, which included 7 hospitals and 1 radiologic clinic, corresponding 12.6% of 1, 265 recorded cases in the state.[29]

Chart 2. Register of infected cases and deaths in health workers

Data of register	Country (City)	Total of infected Healthcare Workers - n (%)	Total of registered cases of infection in general population – n	Death - n
February 11, 2020	China (Wuhan)	1,716 (3.5 to 29)	-	06
February 20, 2020	China (Hubei)	1,809 (88)	2055	22
February 24, 2020	China	3,387 (4.4)	77, 262	23
March 31, 2020	China	0	42, 600	-
March 31, 2020	Italy	-	11,591	61
April 16, 2020	Italy	17,306 (10.7)	162,004	-
March 31, 2020	Spain	5,400 (14)	38,571	-
Feb to April 09, 2020	USA	9,282 (19)	315,531	27
April 11, 2020	Australia	159 (12.6)	1,265	-
April 15, 2020	Brazil	552 (13.8)	4,000	30

In Brazil, we could not found data describing the total of infections by COVID-19 among HCW in our search. However, the Brazil's Federal Council of Nursing (COFEN) reported that 4,000 nursing professionals were took from their job position due suspected or confirmed of COVID-19 (552 already with confirmed diagnosis) [30] (Chart 2).

Deaths

In China, up to February 11, 2002, according to Koh 2020, there were reports of 6 deaths among 1,716 cases of COVID-19 in HCW.[17] In February 20, 2020, Wang 2020 reported 22 deaths of HCW among 2,055 confirmed cases (1.07%).[21] However, in 3,387 cases of HCW that occurred up to February 24, 2020, there were 1 more death until April 04, 2020, which made up 23 death (0.68%). Individuals mean age was 55.3±13.2 years, of them 13 (56.5%) were older than 60 years of age.[23]

In Italy, a total of 24 deaths of HCW were reported among 4,284 cases of COVID-19 until 22 March, 2020 (0.6%).[31] A total of 37 more deaths were reported until March 31, 2020, totalizing 61 deaths of HCW among 11,591 deaths that occurred in the country.[32] In the USA, 27 deaths of HCW were reported from February 12 to April 9, 2020.[24,27] In Brazil, although data are scarce, the COFEN reported 30 deaths of nursing workers due to COVID-19 until April 11, 2020.[30]

The website Medscape that honor HCW who died because of the pandemic reported 605 deaths up to April 22, 2020. Of these 135 were in the USA (22.3%), 109 in Italy (18.0%), and 84 in Ira (13.9%).[33] In Medcape there is a report of 21 deaths in Brazil (3.5%) (Appendix 3).

Discussion

The objective of this systematic review was to identify evidences concerning infection-related risk factors and deaths of HCW involved in treatment of COVID-19 patients.

Evidences found were originated from the opinion of experts observed in cross-sectional and retrospective studies. Because COVID-19 is caused by infectious agent that was identified only few months ago, there were no expectations of studies with an adequate follow-up.

In relation to infection-related risk factor, we highlight the fact that for measures of HCW protection, the use of PPEs is key. We emphasize the importance of adequate training on handling PPE, for example, donning and removing of PPE.[14] However, the routine and habits may constitute potential risk for contamination among the HCW are also highly relevant. In this sense, we must establish a strategy with reason to change habits, raising awareness of HCW that transmission can also happen during meals and group meetings.[34]

Although data related to infection and deaths by COVID-19 among HCW are still little, the behavior of transmission in China during the last months suggests that adoption of protective measures along with training and adequate work load constitute an effective strategy to control of transmission of SARS-CoV-2 among HCW. Initially, the great contamination was due to the lack of knowledge of the etiologic agent and its contagious form, followed by the scarcity of PPE to address the high demand.[20,21] After solving the provision of PPE associated with training related

to adequate use of PPEs, a reduction of new registed cases was seen in terms of infection of HCW. Other factors also contributed to the reduction, such as reduced work load due to low demand of patient which was a resulted from social isolating measures, and due to task forcing by recruiting of new HCW from other locations that were transferred to Wuhan.[24] This finding agree with those observed in other countries, specially Italy, Spain, and the United States that presented overload of health system.[26]

Other aspect that drawn the attention is finding that more than half of HCW who died in China were younger than 60 years[23], and significant amount of severe cases in OS,[25,35] which suggested that continuous exposition to environment with higher risk of transmission and possible contagious with elevated viral load can influence in the progress of the disease.

Data from Basic Network of Health Municipality Secretary of City of Sao Paulo constituted of 64,694 workers showed that in April 22, 2020, 1,666 HCW were took from their job position because they had flu syndrome; 404 were diagnosed with SARS-CoV-2 (accumulated), of these 6 deaths because of COVID-19.[36]

Concerning infected areas at work (Table 1), we observe that there were greater percentage of infected professionals in wards. A hypothesis would be the fact that behavior of professionals in ward environments presents a less careful one in terms of biosafety compared with other professionals at other units, such as ICU.[37,38]

In relation to strategies to deal with current situation of pandemic, we could mention that provision of PPEs, adequate training and reinforcement of the habit of use of PPE, eye protection, and the adoption of standard precaution.[1,12,21,25] In addition, there is need to establish measures to control transmission in a universal format in the hospital environment, even when in contact only with patients without suspection of COVID-19 or with other workers.[34] Other strategies include the restriction at work by adopting isolation in cases of symptoms, frequent testing, intensive training for management of severe and moderate cases, transference of professionals for the most affected areas, clear and easy communication, and establishment of simple and accessible protocols. Studies recommend the screening for fever and possible symptoms of COVID-19 in the beginning of work shift of HCW. Rapid testing must be systematically conducted.[31]

This rapid systematic review included low-evidence level studies, which can be seen as a limitation of our review. Such fact is explained given that this disease has fewer reports on the subject, more precisely, since December 2019.

Conclusion

Data of infection and deaths of HCW due to COVID-19 are related to initial period of the pandemic. This rapid systematic review suggests that risk factors for contagious includes the scarcity of PPE, the work overload, the insufficient ability of HCW to adopt adequate using of protective measures, as well as maintenance of less careful behaviors to aspects that involve habits of biosafety. Behavior of cases in China, Italy, USA, and Spain suggests that overload of health system is an important factor for the infection of healthcare workers. Measures to educate professionals and reduce risks are still limited, especially because few studies had approached the topic and also for the low strength of available evidences.

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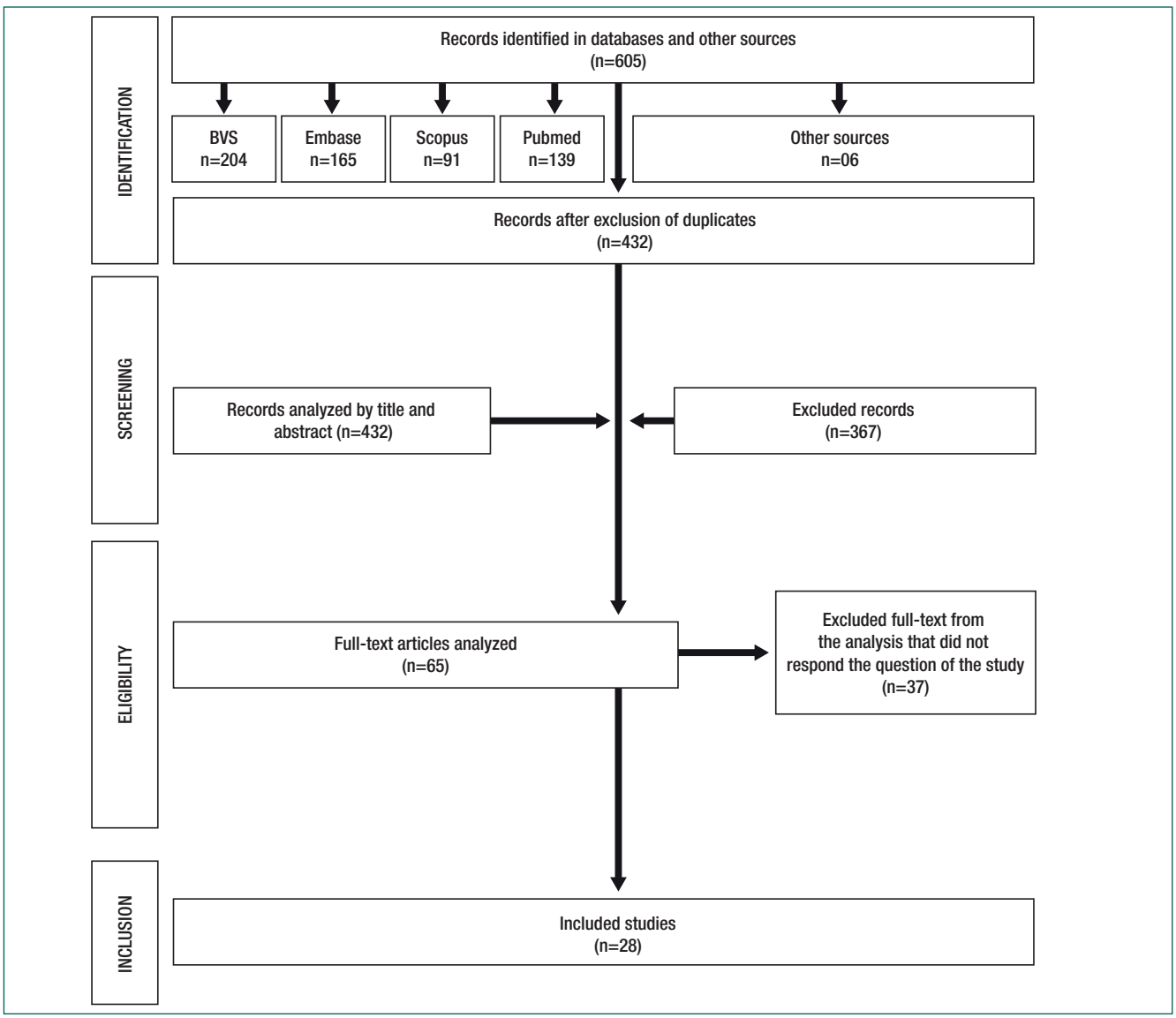
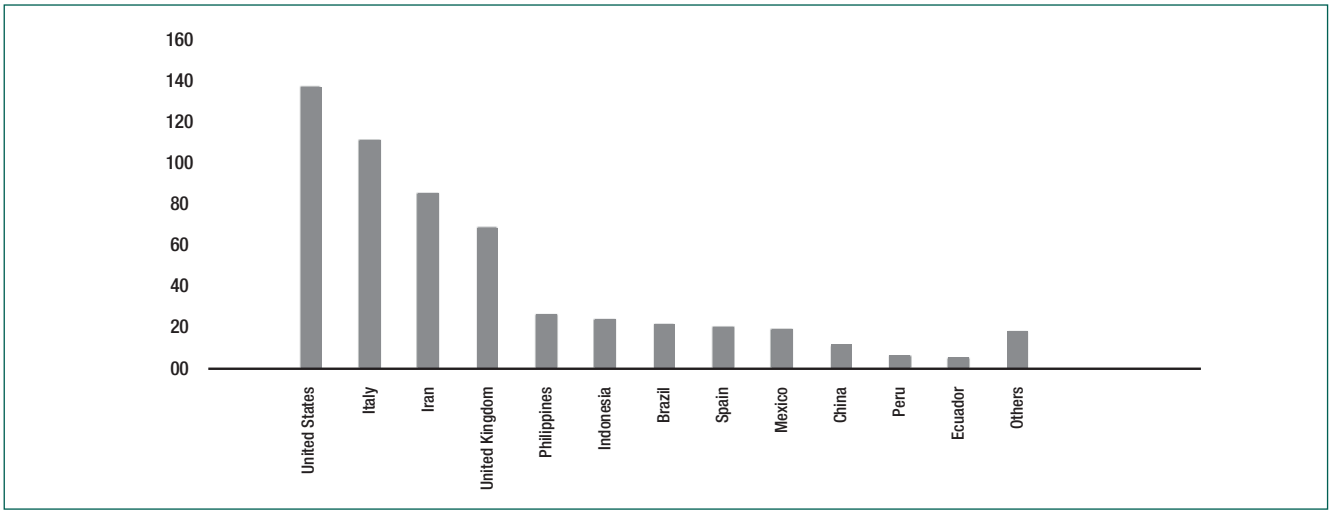
Appendix 1. Database and search strategies

DATABASE	STRATEGIES	RESULT
Scopus	(title-abs-key ("health personnel") or title-abs-key (personnel, and health) or title-abs-key (health and care and providers) or title-abs-key (health and care and provider) or title-abs-key (provider, and health and care) or title-abs-key (providers, and health and care) or title-abs-key (healthcare and providers) or title-abs-key (healthcare and provider) or title-abs-key (provider, and healthcare) or title-abs-key (providers, and healthcare) or title-abs-key (healthcare and workers) or title-abs-key (healthcare and worker) and title-abs-key ("covid-19") or title-abs-key (2019 novel and coronavirus and infection) or title-abs-key (2019-ncov and infection) or title-abs-key (covid-19 and pandemic) or title-abs-key (coronavirus and disease-19) or title-abs-key (2019-ncov and disease) or title-abs-key (covid19 2019 novel and coronavirus and disease) or title-abs-key (coronavirus and disease 2019))	91
VHL Regional Portal	((tw:(Health Personnel)) OR (tw:(Personnel, Health)) OR (tw:(Health Care Providers)) OR (tw:(Health Care Provider)) OR (tw:(Provider, Health Care)) OR (tw:(Providers, Health Care)) OR (tw:(Healthcare Providers)) OR (tw:(Healthcare Provider)) OR (tw:(Provider, Healthcare)) OR (tw:(Providers, Healthcare)) OR (tw:(Healthcare Workers)) OR (tw:(Healthcare Worker))) AND ((tw:(COVID-19)) OR (tw:(2019 novel coronavirus infection)) OR (tw:(2019 novel coronavirus infection)) OR (tw:(2019-nCoV infection)) OR (tw:(COVID-19 pandemic)) OR (tw:(coronavirus disease-19)) OR (tw:(2019-nCoV disease)) OR (tw:(COVID19 2019 novel coronavirus disease)) OR (tw:(coronavirus disease 2019)))	204
Pubmed	((((“Health Personnel”[Mesh] OR personnel, health OR health care providers OR health care provider OR providers, health care OR providers, health care OR healthcare providers OR healthcare provider OR providers, healthcare OR providers, healthcare OR healthcare workers OR healthcare worker)))) AND (((“COVID-19”[Supplementary Concept] OR 2019 novel coronavirus infection OR 2019 novel coronavirus infection OR 2019-ncov infection OR covid-19 pandemic OR coronavirus disease-19 OR 2019-ncov disease OR covid19 2019 novel coronavirus disease OR coronavirus disease 2019)))	139
Embase	‘health care personnel’/exp OR ‘health care personnel’ AND ‘covid 19’/exp OR ‘covid 19’	165



Source: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. PLoS Med. 2009;6(7):e1000097.[15]

Appendix 2. PRISMA flowchart for study selection and inclusion process



Appendix 3. Health workers who have died of COVID-19 - Medscape (April/2020)