



## Coronavirus Disease (COVID-19) and the Critical Role of Healthcare Professionals: A Systematic Review

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**DOI:** 10.31080/ASMS.2020.05.0828

**Received:** December 12, 2020

**Published:** January 11, 2021

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### Abstract

**Objective:** To investigate the factors related to HCW exposition and infection by coronavirus SARS-CoV-2 (COVID-19).

**Methods:** The study was reported according to PRISMA Statement guidelines. The work protocol was registered on International Prospective Register of Systematic Reviews – PROSPERO (CRD42020200236) and eligibility criteria were defined in relation to PICOS. PubMed, EMBASE, Web of Science and SCOPUS were systematically searched, considering related key MeSH (Medical Subject Headings) terms. We considered case reports, case series and clinical researches published in peer-reviewed journals, that have addressed epidemiological and protective features of HCW and its association with COVID-19 exposure and infection. The selected studies brought information about HCW that were exposed and/or infected by COVID-19. We evaluated the exposition and infection data related to occupational characteristics and protective measures adopted by HCW.

**Results:** Eighteen studies reported the characteristics in 10,103 HCW exposed or infected by COVID-19; associations of male (n = 1,448; 30.5%); exposed HCW (n = 746; 7.38%) and infected professionals (n = 523; 5.17%); of 274 professionals positive for the COVID-19, 132 (48.17%) were nurses, 87 (31.75%) were doctors, 33 (12.05%) were dentists and 22 (8.04%) were HCW from other occupations; 2,288 of them (67.59%) reported wearing face-shield, 2,287 (67.56%) face mask, 2,089 (61.71%) protective clothes, 77 (2.27%) gloves and 24 (0.71%) shoe cover; of 196 HCW, 123 (62.75%) reported hand washing as a preventive measure.

**Conclusions:** Health care professionals, especially those with direct contact with infected patients, leading to greater exposition, should take extra precautions to avoid COVID-19 contamination during the current pandemic.

**Keywords:** Covid-19; SARSCoV-2; Health Care Worker; Transmission; Exposure

## Introduction

Since the end of 2019, new pneumonia of viral origin initially reported in the city of Wuhan, China, has received great importance. The World Health Organization, on January 30, 2020, registered this infectious disease, Severe Acute Respiratory Syndrome Coronavirus two (SARS-CoV-2), as a public health emergency of international interest [1]. With a high degree of transmission, the Coronavirus disease 2019 (COVID-19) was registered as a pandemic on March 11, 2020 [2].

Elderly people or those with pre-existing comorbidities, such as hypertension, diabetes, heart disease, lung disease and obesity, may be at greater risk of presenting severe symptoms of these diseases [3]. The COVID-19 symptoms are vast, such as fever, headache, myalgia/arthritis, fatigue, diarrhea and respiratory symptoms, such as coughing and nasal congestion [4-6]. The severity of the disease can vary from mild symptoms, or even asymptomatic, to more severe cases, requiring ICU admission and possibly leading to death [4,5,7,8].

The main route of viral dissemination is through aerosols from the airways of infected patients [9-11]. Hospitalized patients, especially those who need airway management, are great sources of exposure to healthcare professionals [9,10]. Moreover, even professionals who are not in a hospital environment may be at high risk of infection. It can be highlighted cases of dentistry professionals, who perform aerosol-generating procedures in patients, some who may be infected but without symptoms [12,13]. Therefore, hospital and outpatient environments present a high risk of contamination to these professionals by COVID-19.

Cross infection in a hospital environment is an important factor to be considered [14]. A wide spread of Covid-19 can be explained by the possibility of transmission from an asymptomatic patient or with mild symptoms, to healthy people [15-17]. In the report by China government published the data about infection of 3,019 healthcare professionals, with 5 fatal cases [18]. Thus, if the proper biosecurity measures are not taken, both patients have the possibility to infect health care workers (HCW), in the same way that these professionals can take the virus to healthy patients [14,19].

The use of personal protective equipment (PPE) is an important and effective way of preventing transmission. The PPE user had decreased risk from contracting the disease, even as preventing its spread if he is already ill, pre-symptomatically or asymptotically [15,19]. The correct use of equipment such as masks, gloves and appropriate clothing, as well as appropriate preventive procedures, in ambulatory ambient or surgical center, is essential in a pandemic [9,20].

However, the ongoing situation has urgently sought for constructive information about the known features of coronavirus SARS-CoV-2 attack, its risk factors of infecting people and predictors of health for care professionals. Further, it is necessary to better discuss the current global disease situation. Thus, the present systematic review aimed to investigate the risk and predictors factors associated with exposure and infection by coronavirus SARS-CoV-2 of health care professionals.

## Materials and Methods

To ensure standardization this systematic review and was reported according to the National Health Service Centre for Reviews and Dissemination [21] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA Statement) guidelines [22].

The complete work protocol was registered on the International Prospective Register of Systematic Reviews – PROSPERO (CRD42020200236). Eligibility criteria were defined in relation to PICOS (participants, interventions, comparisons, outcomes, and study design) as recommended by PRISMA Statement. This systematic review asked the following questions 1) Is being a health professional a risk factor in the COVID-19 pandemic?; 2) Are exposure and occupational factors determinants for COVID-19 infection?; and 3) Are health professionals performing the protection procedures correctly?

## Search strategy and selection criteria

PubMed, EMBASE, Web of Science and SCOPUS were systematically searched, considering the following key MeSH (Medical Subject Headings) terms: “Covid-19” AND “Transmission” AND “Health care worker”; “Covid-19” AND “Transmission” AND “Health care

professional”; “Covid-19” AND “Transmission” AND “Exposure”. Furthermore, the reference list was reviewed to identify other potentially relevant studies. The last search conducted was on July 1<sup>st</sup> 2020.

As eligibility criteria, we considered case reports, case series and clinical researches in all languages, published in peer-reviewed journals, that have addressed epidemiological and protective features of Health care workers and its association with COVID-19 exposure and infection. Duplicate publications and articles that did not correspond to the objectives of this systematic review were excluded. Similarly, publications without a research or case report, such as: descriptive studies; opinion article; correspondence; editorials and letters to the editor were also excluded. Figure 1 shows the steps of the searched literature.

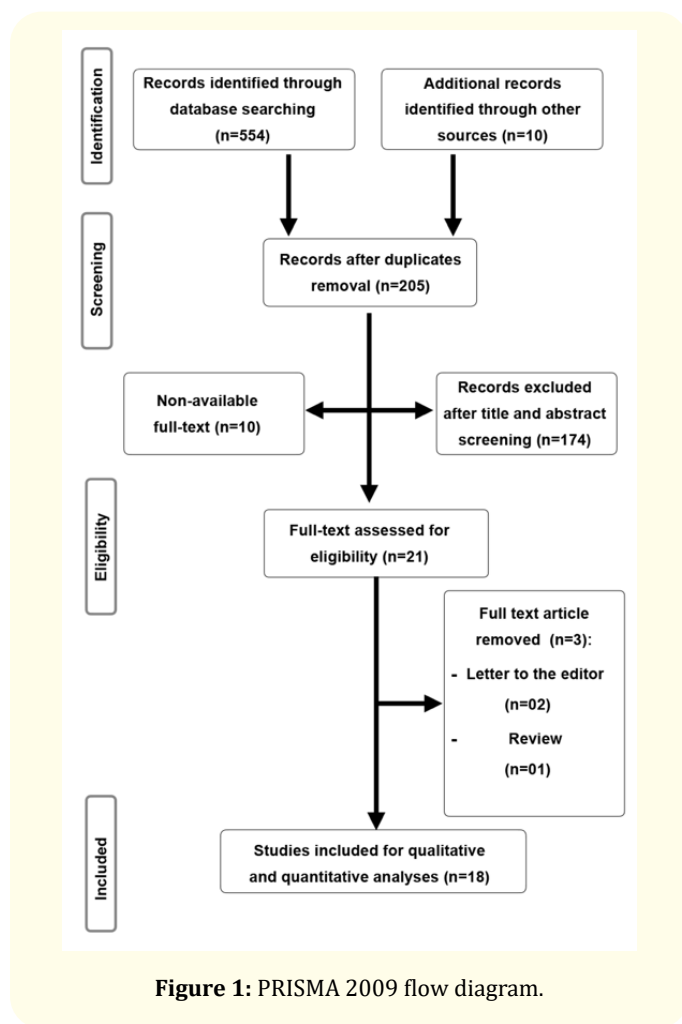


Figure 1: PRISMA 2009 flow diagram.

### Data extraction

Two investigators participated through each phase of the review and independently screened the titles and abstracts yielded by the search against the inclusion criteria. The authors screened the full text reports and decided whether met the inclusion criteria. Discrepancies between the reviewers were resolved by discussion and consensus and final results were reviewed by a senior investigator. The following data were extracted from the included: study design, methodology, year of data collection, sample size and characteristics, outcomes, case definition, exposure and comparators.

### Quality appraisal and risk of bias (ROB)

Cohort, case-control and cross-sectional studies were appraised by appropriate tools for each study design by the investigators.

Nine points were assigned of up to a maximum for the least risk of bias in three domains through the Newcastle-Ottawa Scale (NOS) and NOS-derived survey scale: 1) selection of study groups (0-4 points); 2) comparability of groups (0-2 points); and 3) ascertainment of exposure and outcomes (0-3 points) for cross-sectional, case-control and cohort studies [23]. Scoring was undertaken by two reviewers, with a third reviewer resolving any disagreements. Studies were considered at low risk of bias (ROB) when the overall scores were 9–10; moderate when scores were 6–8; and high when the score were 0–5. Research questions were developed based on the NOS’ questions covering all three domains so that authors could provide detailed information about their studies.

### Summary measures

Quantitative data were grouped by some variables: prevalence of HCW infected, transmission risk, occupation, use of proper protective measures. The data were analyzed and grouped by 2 researchers and the tabulation of all data was performed by only one researcher. After all tabulation, the data were reviewed by another researcher. This decreased the possibility of disagreements.

### Results and Discussion

#### Scientific information database

The flowchart illustrating the selection of studies for inclusion in the systematic review is shown in Figure 1. The search process in all scientific database led to 564 articles, which after removing unrelated and duplicate articles, 21 cases were assessed for eligibility. Finally, 18 articles remained for qualitative and quantitative analysis.

**Studies characteristics**

Eighteen articles entered to the final step of the systematic review and meta-analysis. The studies quality assessment using NOS indicated that their NOS ranging from 6 to 9, so the studies had moderate quality.

All articles assessed the relationship between COVID-19 exposition and infection among HCW. In addition to basic demographic information, we extracted also other important information for the analyses: degree of exposition according to the studies, use of PPE and hygiene measures and work occupation.

**Subgroup and overall summary of the relationship between covid-19 infection in HCW**

A detailed description of the studies included is shown in table 1. Eight of the 18 articles were retrospective Cohort studies, one

was prospective Cohort, eight cross-sectional and one was a case series. The association of HCW exposed and infected by COVID-19 was already expected, given the potential risk of infection in these professionals. In the pooled data from the studies (n = 10,103) that have reported the characteristics in HCW exposed or infected by COVID-19; associations of male (n = 1,448; 30.5%), respectively (Table 1).

**Exposition and infection data**

Of the 18 articles that were selected for analysis, 10 of them brought the information of HCW that was actively exposed to the Coronavirus and 16 brought the number of HCW with confirmation of infection with the virus. The number of exposed and infected professionals was respectively, 746 (7.38%) and 523 (5.17%) (Table 1).

Study	Guan, et al. 2020	Heinzerling, et al. 2020	Jin, et al. 2020	Li, et al. 2020	McMichael, et al. 2020	Roxby, et al. 2020	Wang, et al. 2020	Wei, et al. 2020	Zhang, et al. 2020	Li, et al. 2020	Lan, et al. 2020	Ran, et al. 2020	Bergh, et al. 2020	Liu, et al. 2020	Liang, et al. 2020	Vera, et al. 2020	Yin, et al. 2020	Moraes, et al. 2020	N Total (%)
Location	China	Solano County, USA	Wuhan, China	Wuhan, China	King County, USA	Seattle, USA	Wuhan, China	Wuhan, China	Wuhan, China	Wuhan, China	Asian countries	Wuhan, China	Netherlands	Wuhan, China	Singapore	Switzerland	China	Brazil	
New Castle Scale (NOS)	7	7	8	8	6	8	9	8	9	8	7	8	8	9	7	8	8	8	
Type of study	Retrospective Cohort	Retrospective Cohort	Cross-sectional	Retrospective Cohort	Retrospective Cohort	Cross-sectional	Cross-sectional	Prospective cohort	Cross-sectional	Retrospective Cohort	Retrospective Cohort	Retrospective Cohort	Cross-sectional	Retrospective Case series	Retrospective Cohort	Cross-sectional study	Cross-sectional study	Cross-sectional study	
Total patients	1,099	43	103	425	167	6	138	14	140	25	690	72	1,353	64	2,250	21	371	3,122	
HCW exposed to Coronavirus	-	43	103	-	-	-	-	14	-	11	-	55	3	11	-	21	359	126	746 (7.38)

HCW positive for COVID-19	38 (3.5)	3	103	15	50	2	40	14	3	12	23	28	86	64	9	-	-	33	523 (5.17)
Age	47	39	35	59	72	-	56	36	57	48.4	-	31	49	35	-	40	35.3	38	45.18
Gender																			5,844 (100)
Female	459	36	62	240	112	2	63	10	69	13	-	50	34	41	-	14	228	2,326	3,759 (64.32)
Male	637	7	39	185	55	0	75	4	71	12	-	22	15	23	-	7	143	790	2,085 (35.68)
Exposure																			719 (100)
High risk	-	5	32	-	-	-	-	-	-	11	-	33	-	11	-	6	228	126	452 (72.86)
Middle risk	-	36	-	-	-	-	-	-	-	-	-	-	-	-	-	12	71	-	119 (16.56)
Low risk	-	2	71	-	-	-	-	14	-	1	-	39	-	-	-	9	12	-	148 (20.58)
Occupation																			3,755 (100)
Doctor	-	3	41	-	-	-	-	2	-	-	3	19	-	21	1	5	67	-	159 (4.23)
Nurse	-	22	55	-	-	-	-	12	-	-	10	9	-	43	3	14	264	-	410 (10.92)
Dentist	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,122	3,122 (83.15)
Other	-	18	7	-	-	-	-	-	-	-	10	-	-	-	5	2	40	-	64 (1.7)
HCW infected																			274 (100)
Doctor	-	-	41	-	-	-	-	2	-	-	3	19	-	21	1	-	-	-	87 (31.75)
Nurse	-	-	55	-	-	-	-	12	-	-	10	9	-	43	3	-	-	-	132 (48.17)
Dentist	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	33 (12.05)
Other	-	-	7	-	-	-	-	-	-	-	10	-	-	-	5	-	-	-	22 (8.04)

PPE																			3,385 (100)
Face mask	-	3	68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,216	2,287 (67.56)
Gloves	-	24	53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77 (2.27)
Protection clothes	-	0	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,060	2,262
Face shield	-	-	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,089 (61.71)
Shoe covers	-	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yes	-	-	-	-	-	-	-	-	-	-	23	-	-	-	0	-	-	-	2,288 (67.59)
No	-	-	-	-	-	-	-	-	-	-	49	-	-	-	21	-	-	-	24 (0.71)
Hand washing	-	-	80	-	-	-	-	-	-	-	22	-	-	-	21	-	-	-	23 (0.68)
																			70 (2.07)
																			123/ 196 (62.75)

**Table 1:** Demographic characterization and information of Studies included.

In our study, the risk of exposure to the virus was divided into high, medium and low risk. This classification was performed according to the data obtained in the analysis of the data obtained in the studies. The data was extracted from 9 articles, totaling a total of 719 HCW with risk of exposure. The stratification regarding the risk of exposure in our studies was related to the sectors of work and procedures developed by professionals. Four hundred and fifty-two (72.86%) professionals had high exposure to infection, followed by 119 (16.56%) with medium exposure and 148 (20.58%) who had low exposure to COVID-19 (Table 1).

**Occupational characteristics**

The occupational characterization in all available studies to-date in HCW exposed to or infected with COVID-19 was also summarized in Table 1. Ten articles reported the occupation of health

professionals who participated in the studies (n = 3,755). Of these, 7 brought information from health professionals who were infected with the novel coronavirus (n = 274).

The professionals were stratified according to the representative number in our review: 3,122 (83.15%) were dentists, 410 (10.92%) were nurses, 159 (4.23%) were doctors and other occupations totaled 64 (1.7%). Of the 274 professionals who were positive for the coronavirus, 132 (48.17%) were nurses, 87 (31.75%) were doctors, 33 (12.05%) were dentists and 22 (8.04%) were HCW from other occupations.

**Use of PPE and hand washing**

Another important information obtained in the studies was the preventive measures adopted by HCW. Five of the articles brought information on the use of personal protective equipment, while 3

had the information on the number of HCWs who used hand washing as a measure to prevent infection and dissemination of the coronavirus. None of the studies relate aerosol exposure data to the use of specific PPE.

The total number of professionals who reported the use of PPE was 3,385. Two thousand two hundred and eighty-eight of them (67.59%) reported wearing a face-shield, 2,287 (67.56%) reported using face mask during procedures, 2,089 (61.71%) used protective clothing, 77 (2.27%) reported using gloves and 24 (0.71%) used protection for shoes. In these studies, 70 (2.07%) health care workers reported not using PPE correctly and 23 (0.68%) reported always using PPE correctly (Table 1).

Of the 3 studies that evaluated hand washing, with a total of 196 HCW questioned, 123 (62.75%) reported hand washing as a preventive measure during the procedures performed (Table 1).

## Discussion

The present study systematically reviewed the risk factors associated with exposure and infection of health care professionals by coronavirus 2.

Since past epidemics, it is already known that infection among HCW's can consist of a critical situation. In addition to the possibility of direct transmission to patients, it can also enable indirect transmission through health care equipment [19,24]. The exposure risk factor can also predict the risk of infection with the virus due to the high transmissibility potential of the coronavirus [17,25]. Professionals in direct contact during care for infected patients and those who undergo exposure to airborne generating procedures, have a greater risk of contracting COVID-19 [26,27]. In the present review, among the 746 professionals that related exposure to infected patients, 523 (70.1%) were infected by coronavirus.

Of the 746 professionals who were infected with the coronavirus, we can observe a heterogeneity in the percentage in each study: 100% [28], 100% [29], 100% [30], 48% [31], 38.9% [26], 33.3% [32], 29.9% [33], 7% [34], 6.3% [35], 3.5% [6], 3.5% [36], 3.3% [37], 2.1% [24], 1.1% [13] and 0.4% [38]. This fact occurred due to the difference in the design of each survey. In our study, the

selected studies had different populations evaluated: health professionals in a larger group of non-HCW patients, health professionals exposed and tested for COVID-19, and specific groups of health professionals positive for coronavirus.

It can be observed that according to the recent studies developed to evaluate exposure and infection to COVID-19, nursing professionals account for the highest percentage of professionals with the highest risk of exposure to Coronavirus (47.2% [26], 53.4% [28], 85.7% [29], 67% [20], 51% [34], 10% [37], 67% [39] and 71.2% [40]). This number is followed by doctors (52.8% [26], 39.8% [28], 14.3% [29], 33% [30], 7% [34], 3% [30], 24% [40] and 18.1% [41]), who also work face-to-face with infected or possibly infected patients. And finally, dental professionals (5.3% [13]), who perform aerosol-generating procedures in daily practice. However, other professionals, such as radiology technicians, nursing technicians and physiotherapists, are also at risk for coronavirus exposure.

Another important factor to be considered is that, of the selected studies, not all professionals who were exposed in some way to the coronavirus tested positive. This fact is probably due to the correct use of safety measures and personal protective equipment. In Heinzerling, *et al.* 2020 [34], of the 43 professionals exposed to the coronavirus, only 3 tested positive. Also, in the study developed by Moraes, *et al.* 2020 [13], of 126 dentists who had direct contact with positive patients, only 33 were infected.

A recent study developed [41] showed that the greater HCW's knowledge, greater influences their attitudes against the spread of the virus and in favor to the health of patients. Knowing the main routes of transmission and measures to reduce exposure and, consequently, infection, is an effective form of prevention. The importance of using PPE is an important knowledge that must be present in HCWs working during the pandemic of the novel coronavirus [10,20,42]. Equipment such as protective clothing (67.59%), face masks (67.56%) and face-shields (63.99%), were the PPE that had the most reported use for protection [13,28]. In addition to the use of PPE, the most used prevention measure reported in the articles was hand washing. From the general population of the studies that evaluated hand washing, 62.75% (n = 196) of the individuals used the washing of this measure as an infection prevention.

Our study has several limitations. First, despite our inclusion criteria, there were differences in study design and significant heterogeneity between studies for several interventions, probably reflecting in our data extraction. We identified many gaps in the literature, such as protective measures, degree of formation and knowledge, and infection related to occupation, which should be investigated to provide a standardized protocol for preventing the HCW to coronavirus infection.

## Conclusion

This systematic review revealed that health care professionals, especially those with direct contact with infected patients, leading to greater exposition, should take extra precautions to avoid COVID-19 contamination during the current pandemic. The fact of being a health professional in itself, proved to be a risk factor for exposure to COVID-19. And finally, although health professionals should take extra preventive, many have not shown frequency in adopting these measures.

## Acknowledgements

The authors are grateful for University of São Paulo and financial support provided by São Paulo Research Foundation (FAPESP) Grant number 18/25934-0 and Coordination for the Improvement of Higher Education Personnel - Finance code 001.

## Conflict of Interest

All authors declare none conflicts of interest.

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