

Use of personal protective equipment to care for patients with COVID-19: scoping review



Utilização de equipamentos de proteção individual para atendimento de pacientes com COVID-19: revisão de escopo

Uso de equipo de protección personal para el cuidado de pacientes con COVID-19: revisión del alcance

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ABSTRACT

Objective: To summarize the knowledge about recommendations for the use of personal protective equipment necessary for the provision of care by health professionals to patients suspected or infected by the new coronavirus.

Method: Scoping review with search for primary studies, reviews and preprints articles in English, Portuguese and Spanish, in the last 20 years on the bases WOS/ISI, SCOPUS, MEDLINE/PuBMed, CINAHL, LILACS and SciELO. Unpublished studies in journals were surveyed on bioRxiv and SciELO preprints.

Results: 23 studies were eligible. Experiences with coronavirus prior to SARS-CoV-2 revealed that the equipment was an essential barrier in preventing transmission and followed the recommendations for standard precautions, contact, droplet and aerosol. In 13 (57%) studies, this equipment complied international recommendations and in 10 (45%) local recommendations.

Conclusion: The personal protective equipment used does not follow global standardization according to type, quality and adequate provision, exposing these professionals to the risk of contamination.

Keywords: Coronavirus infections. Personal protective equipment. Health personnel.

RESUMO

Objetivo: Sumarizar o conhecimento sobre recomendações do uso de equipamentos de proteção individual necessários para a prestação do cuidado por profissionais de saúde à pacientes suspeitos ou infectados pelo novo coronavírus.

Método: Scoping review com busca de estudos primários, revisões e artigos preprints em inglês, português e espanhol, nos últimos 20 anos nas bases WOS/ISI, SCOPUS, MEDLINE/PuBMed, CINAHL, LILACS e SciELO. Estudos não publicados em periódicos foram levantados nos Preprints bioRxiv e SciELO preprints.

Resultados: 23 estudos foram elegíveis. Experiências com coronavírus anteriores ao SARS-CoV-2 revelaram que os equipamentos foram barreiras imprescindíveis na prevenção da transmissão e seguiram recomendações de precauções padrão, contato, gotícula e aerossol. Em 13 (57%) estudos esses equipamentos atenderam às recomendações internacionais e em 10 (45%) recomendações locais.

Conclusão: Os equipamentos de proteção individual utilizados não seguem padronização global segundo tipo, qualidade e provisão adequada, expondo esses profissionais ao risco de contaminação.

Palavras-chave: Infecções por coronavírus. Equipamento de proteção individual. Pessoal de saúde.

RESUMEN

Objetivo: Resumir el conocimiento sobre las recomendaciones para el uso de equipos de protección personal necesarios para la prestación de cuidados por parte de los profesionales de salud a pacientes sospechosos o infectados por el nuevo coronavirus.

Método: Revisión de alcance con búsqueda de estudios primarios, revisiones y preprints en inglés, portugués y español, en los últimos 20 años en bases WOS/ISI, SCOPUS, MEDLINE/PuBMed, CINAHL, LILACS y SciELO. Estudios no publicados en revistas se encontraron en Preprints bioRxiv y SciELO preprints.

Resultados: 23 estudios fueron elegibles. Experiencias con coronavirus antes del SARS-CoV-2 revelaron que el equipo era una barrera esencial para prevenir la transmisión y siguieron las recomendaciones de precauciones estándar, contacto, gotas y aerosoles. En 13 (57%) estudios este equipo cumplió con las recomendaciones internacionales y en 10 (45%) recomendaciones locales.

Conclusión: El equipo de protección personal utilizado no sigue la estandarización global según tipo, calidad y provisión adecuada, exponiendo a estos profesionales al riesgo de contaminación.

Palabras clave: Infecciones por coronavirus. Equipo de protección personal. Personal de salud.

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■ INTRODUCTION

The virus Severe Acute Respiratory Syndrome-related Coronavirus-2 (SARS-CoV-2) is the causative agent of the disease called coronavirus disease (COVID-19)⁽¹⁾. SARS-CoV-2 is transmitted by contact between people through respiratory droplets expelled during speech, coughing and sneezing. Transmission can also occur through indirect contact with contaminated objects and surfaces. The virus penetrates through the mucous membranes of the mouth, nose and eyes, and acts mainly on the respiratory tract⁽¹⁻²⁾. The clinical manifestations of SARS-CoV-2 infection can range from a simple cold to Severe Acute Respiratory Syndrome (SARS). The most common clinical symptoms are: fever, dry cough, myalgia, fatigue, dyspnea and, in less frequency, sore throat, hemoptysis, headache, dizziness, diarrhea, nausea/vomiting, chest and/or abdominal pain, and also to anosmia/hyposmia and dysgeusia⁽³⁻⁵⁾.

SARS-CoV-2 has high and fast transmissibility, and the speed of dissemination recorded in 185 countries recorded a growth curve of cases with exponential characteristics, and 72 days elapsed between the first case until it became a global pandemic on March 11, 2020^(1,6-7).

According to the Pan American Health Organization (PAHO), coronavirus is the second leading cause for common colds. There are seven known human coronavirus (HCoVs), including SARS-CoV (which causes severe acute respiratory syndrome - SARS), MERS-CoV (which causes Middle East respiratory syndrome - MERS) and the new SARS-CoV-2 (COVID-19)⁽⁷⁾. The transmission rate of SARS-CoV-2 varies from 1.4 to 5.5, and contamination of the human host can occur directly (contact of contaminated aerosols with the mucosa of healthy people) or indirectly (viruses deposited on surfaces, touched by hands can contaminate another person)⁽⁸⁾.

During affection by COVID-19, approximately 80% of people manifest mild cold symptoms, however approximately 20% of cases require hospitalization and 5% evolve severely, requiring support from intensive care units (ICU)⁽⁹⁾.

The recommendations of the World Health Organization (WHO)⁽¹⁰⁾ on the use of personal protective equipment (PPE) reveal that in the preliminary screening of the suspected patient, the professional must maintain a minimum physical distance of one meter and use architectural glass/plastic structures to create a barrier between professionals and patients. When physical distance is not possible, the professional must wear a surgical mask and eye protection. When providing direct care to patients with COVID-19, it is necessary to use surgical mask, cloak, gloves, and eye

protection (goggles or face shield). When providing direct care to patients with COVID-19 in aerosol-generating procedures, the professional must use a N95 mask (FFP2 or FFP3 standard, equivalent or simply "respirator"), cloak, gloves, eye protector and waterproof apron⁽¹⁰⁾.

The Centers for Disease Control and Prevention (CDC)⁽⁴⁾ recommends standard precautions and wear a respirator mask (or face mask, if a respirator is not available), cloak, gloves and eye protection. The professional should wash their hands before and after contact with the patient, with potentially infectious material and before putting on and removing PPE. Hygiene should be done with a 60-95% alcohol solution or with soap and water for at least 20 seconds⁽⁴⁾.

Due to the speed of dissemination of SARS-CoV-2, it was necessary an emergency (re)organization at the global level of health services, with the creation of new care protocols, review of flows, acquisition of supplies such as 70% alcohol in gel, respirators, PPE, and the training of health professionals to meet the demand of infected people. It is noteworthy that in most countries the health systems were not prepared to face the pandemic and the lack of ICU beds, respirators, PPE and health personnel caused an unexpected collapse⁽¹¹⁻¹⁵⁾.

In this context, there was an interest in identifying the knowledge produced about the PPE recommended to health professionals during care practice for patients with COVID-19.

The objective of this research was to summarize the knowledge on recommendations for the use of personal protective equipment necessary for the provision of care by health professionals to patients suspected or infected with the new coronavirus.

■ METHOD

This is a Scoping Review, which aims to address broad topics, focusing on comprehensive and in-depth results of scientific studies. It also allows to identify, examine and systematize in a rigid and effective way a concept or particular characteristics when identifying the nature of a wide field of knowledge⁽¹⁶⁻¹⁸⁾. Considering the pandemic situation, the demand for information and the way of dissemination practiced worldwide, includes unconventional documents, the scope review was selected as the method used in this study.

According to the proposed systematization for scoping review studies, five mandatory stages and one optional are carried out: (1) identification of the research question; (2) identification of relevant studies; (3) selection of studies; (4)

data mapping; (5) data grouping, analysis and summary; and (6) consultation to researchers (optional)⁽¹⁶⁾.

To determine the research question, it was used the Population, Concept and Context (PCC) strategy⁽¹⁹⁾. Thus, the guiding question of this study was: what are the recommendations for the use of personal protective equipment necessary for the provision of care by health professionals to suspected or infected patients with the new coronavirus?

The search for the studies was carried out in April 2020 by two researchers, independently, avoiding bias in the number of articles found. The main health databases were selected for search: Web of Science (WOS/ISI), SCOPUS, Medical Literature Analysis and Retrieval Online (MEDLINE/PuBMed), The Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Latin American and Caribbean Literature in Health Sciences (LILACS). In addition, it was used the Scientific Electronic Library Online (SciELO) library. Unpublished studies in journals were surveyed on the Preprints bioRxiv servers and SciELO preprints, these selected due to the emerging demand for knowledge in the pandemic situation. In order to compare the results of selected studies with international recommendations on the use of PPE, the WHO and CDC websites were searched. These information bases were selected because they have recognition in the academic community and an expressive number of conventional and unconventional documents in the health area.

As for the type of studies included in the search, primary studies, descriptive, review, editorial and manuals published in the last 20 years were inserted, between January 1, 2000 and April 27, 2020, considering the emergence of the first cases of coronavirus (SARS-CoV and MERS-CoV) in year 2000. The selected languages were Portuguese, English and Spanish, with full texts available and which answered the research question. Repeated articles in more than one data source were counted only once. The descriptors selected for this research were recruited through the databases "Health Sciences Descriptors" (DeCS) and "Medical Subject Head Medical Subject Headings" (MESH) being Coronavirus; Coronavirus Infections, the descriptors used with the support of the Boolean operator "OR" with terms restricted

to the subject COVID-19; SARS-CoV; SARS-CoV-2; MERS-CoV. Subsequently, the descriptors Health Personnel and Personal Protective Equipment were crossed with the help of the "AND" operator. These descriptors were inserted in the databases in English language, except for the LILACS database, in which they were inserted in English and Portuguese. In the preprint repositories, the same descriptors in English were used.

To optimize the studies mapping, it was used the software State of the Art through Systematic Review (StArt)⁽²⁰⁾, Beta 3.0 version, to create a review protocol that helped in the process of planning, execution and data analysis.

In sequence, the data were grouped, analyzed, and summarized, which were extracted by two independent reviewers, specialists in occupational health and nursing, with experience in reviews. The doubts and incongruities were analyzed and discussed by a third reviewer, who is a senior researcher with expertise in research in the area and in the method. To ensure double checking of the findings, data extraction was also carried out by two independent reviewers, in each publication the main focuses were identified, listed in the proposal of the investigated question. Data were recorded in a Microsoft Office Excel spreadsheet, version 2010, considering the year of publication, authors, language, place of the research, type of study and the recommendations of WHO, CDC or other institutions.

From the criteria established for this review, 583 articles were found in the researched databases, libraries, and preprints servers. From these, 257 at LILACS, 213 at SciELO, 59 at SCOPUS, 22 at MEDLINE/PuBMed, 15 articles at CINAHL, 4 at WOS/ISI, 2 at COCHRANE, 11 articles in the Preprints bioRxiv repository and no articles were identified in the SciELO preprints repository, these last were entered manually.

Figure 1 shows the flowchart built based on the PRISMA-ScR model⁽¹⁸⁾ to organize and present the stages of identification, screening, eligibility and inclusion of publications.

This research protocol did not require submission to the Research Ethics Committee (CEP), as it adopted documents (articles, consensuses and recommendations) with open access as a data source, ensuring the authorship specification to safeguard their intellectual property.

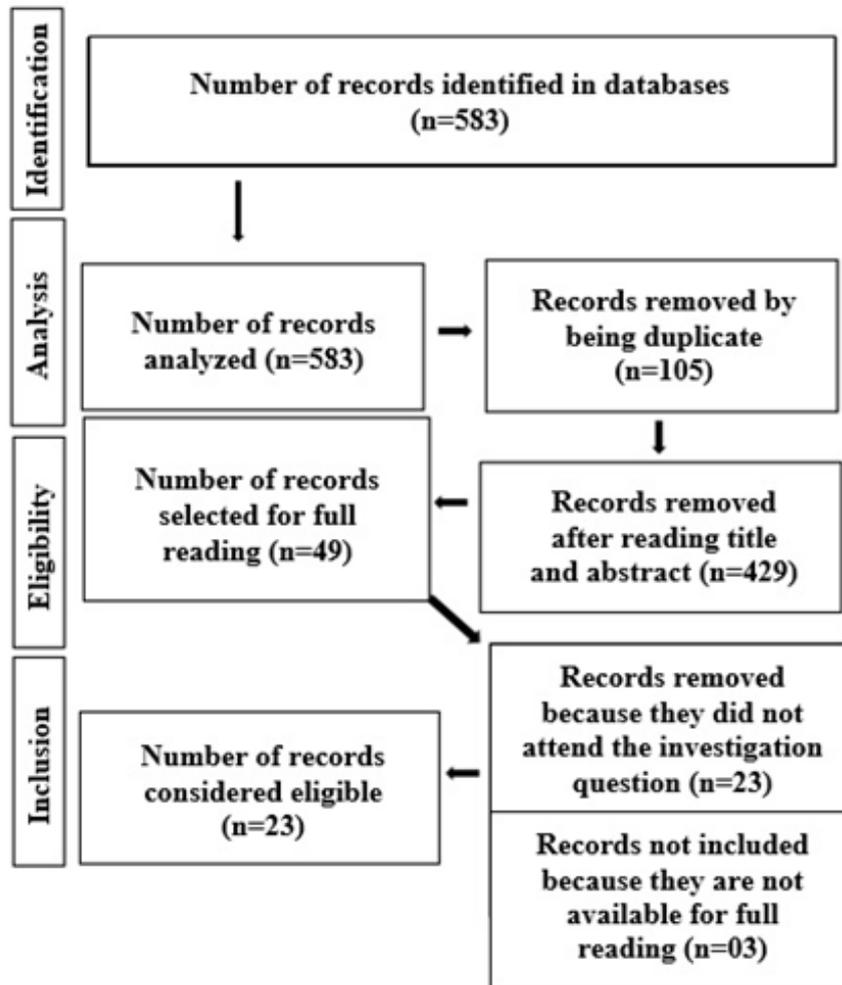


Figure 1 – Adapted PRISMA-ScR flowchart⁽¹⁸⁾. Ribeirão Preto, SP, Brazil, 2020
Source: Adaptation of⁽¹⁸⁾

RESULTS

In this review, 23 studies were analyzed, of which 8 (34.8%) were extracted from SCOPUS, 7 (30.4%) from LILACS, 2 (8.7%) from MEDLINE/PubMed, 2 (8.7%) from CINAHL, 2 (8.7%) from WOS/ISI, 1 (4.3%) from SciELO and 1 (4.3%) from the bioRxiv preprint server. Among these, it was found that 12 (52.2%) studies were published in the period before the pandemic COVID-19^(21–32) and 11 (47.8%) studies were published after the start of the pandemic^(33–43). From the total, 19 (82.6%) studies were published in English^(21–29,31–40), 2 (8.7%) studies were published in Portuguese^(41,43) and 2 (8.7%) in Spanish^(30,42).

The publications were mainly from the United States of America and Saudi Arabia, respectively, with 5 (21.7%)

^(21–22,25–26,33) and 4 (17.4%)^(27,29,31–32) studies. Also from Singapore⁽²³⁾, Taiwan⁽²⁴⁾, Spain⁽³⁰⁾, South Korea⁽²⁸⁾, Korea⁽³⁴⁾, China⁽³⁵⁾, Ireland⁽³⁶⁾, Netherlands⁽³⁷⁾, Italy⁽³⁸⁾, El Salvador⁽⁴⁰⁾, Brazil^(41,43), Paraguay⁽⁴²⁾ and one multicenter study involving researchers from different nationalities⁽³⁹⁾.

As for the type of study, there were 6 (30.4%)^(21–22,25,38–39,43) theoretical, 4 (17.4%) reviews^(26,33,36–37), 3 (13.0%) cross-sectional^(23–24,32), 2 (8.7%) observational cross-sectional^(27–28), 2 (8.7%) editorial^(34–35), 3 (8.7%) recommendations from local authorities^(40–42), 1 (4.3%) analytical observational⁽³⁰⁾, 1 (4.3%) cohort⁽²⁹⁾ e 1 (4.3%) intervention study⁽³¹⁾.

Chart 1 shows the 12 studies (52.1%) published in the period before the pandemic, according to the recommendation for PPE use.

Recommendations regarding the use of PPE			
Authors/year	WHO	CDC	Others
Shapiro SE, McCauley LA ⁽²¹⁾ 2004	Standard precautions, of contact and respiratory when treating suspected SARS customers. N95 adjusted and not reused. Use of surgical masks to limit transmission. Eye protection and hand hygiene before and after contact with the patient.		
Thorne CD, Khozin S ⁽²²⁾ 2004	Hand hygiene, wearing a cloak, gloves, adjusted N95 and eye protection. PPE standardization requires training. In case of aerosol generation, it requires a higher level of respiratory protection, such as hoods or fitted face pieces.		
Chia SE, et al. ⁽²³⁾ 2005			The Singapore Ministry of Health manual recommends hand hygiene and the use of PPE. The recommended PPE are: N95, glasses/face shields, cloak (long sleeve) and disposable gloves.
Yen MY, et al. ⁽²⁴⁾ 2006	N95, eye protection, cloak, and latex gloves.		Taiwan's Department of Health also advises a second layer of outer gloves, apron, head, and foot cover.
Suwantarat N, Apisarntharak, A ⁽²⁵⁾ 2015	Reinforce the use of N95. Training is a key component of using PPE.		
Weber DJ, et al. ⁽²⁶⁾ 2016	Basic individual training on equipping and unequipping PPE, with an explicit written list of all stages of equipping and unequipping.		
Butt TS, et al. ⁽²⁷⁾ 2016	Hand hygiene, environment, and equipment cleaning, use of PPE, such as respirators with high-efficiency particulate (for example, N95).		
Kim CJ, et al. ⁽²⁸⁾ 2016		N95 or powered air-purifying respirator (PAPR), isolation suit (coveralls), goggles or face shield and gloves.	

Chart 1 – Characterization of studies published in a period before the pandemic, considering: Authors; Year of publication; Recommendations from WHO, CDC or others. Ribeirão Preto, SP, Brazil, 2020

Recommendations regarding the use of PPE			
Authors/year	WHO	CDC	Others
Alraddadi BM, et al. ⁽²⁹⁾ 2016			Use of N95 by professionals in close contact with infected patient.
Maestre NMA, et al. ⁽³⁰⁾ 2017			Action measures before a patient's admission. Workers are registered, monitored and trained on the agent's risks, use of appropriate PPE and the protocol implementation for different situations in which the use of PPE is necessary.
Al-Tawfiq JA, et al. ⁽³¹⁾ 2018		Cloak, gloves, head cover (hood) and N95, hand hygiene, PPE equipping and unequipping.	
Saud HA, et al. ⁽³²⁾ 2018	Preventive measures with protection of the nose, eyes, and any other places from which the medical team can contract the disease.		

Chart 1 – Cont.

Source: Research data, 2020.

Among the studies published in the period before the pandemic, 8 (35%) are based on WHO and/or CDC recommendations^(21–22,25–28,31–32), while 3 (13%) presented other types of recommendations^(23,29–30) and 1(4%) was based on the WHO recommendation and the local health department⁽²⁴⁾.

Other recommendations included were: integrated strategy for infection control norms; use of barriers in service; separation of risk zones for infected patients; a second disposable layer of protective clothing; and, installing alcohol dispensers to rub hands, even with gloves⁽²⁴⁾. It also emphasized the importance of choosing PPE and its correct use, including the use of N95, but controlling the risk at source should always be the main guiding principle^(23,29).

Chart 2 shows the 11 (48%) published studies in the period from December 2019 (COVID-19 initial outbreak) to April 27, 2020, according to the recommendations for the use of PPE.

In the COVID-19 pandemic context, it was observed that 4 (26.7%) studies are based on international protocols with relation to PPE and 7 (46.7%) are based on local protocols^(33–43).

At the present time, WHO⁽¹⁰⁾ and CDC⁽⁴⁾ continue with the recommendation of standard precautions for all patients, and the implementation of additional precautions (droplets and contacts and, when applicable, aerosol precautions) for suspected cases and confirmed COVID-19, as well as administrative and environmental controls. Indications for the use of PPE must be taken based on the definition, target audience, risk of exposure and dynamics of transmission of the pathogen. However, it was found that the use of coveralls, double gloves or head covers (hood), according to the recommendations of these agencies, are not necessary when caring for patients with COVID-19, contrary to the local recommendations of some countries like China, Korea and Paraguay^(34–35,39,42).

Recommendations regarding the use of PPE			
Authors/Year	WHO	CDC	Others
Jones RM, et al. ⁽³³⁾ 2020	Eye and face protection, head, and hair protection. Equipment includes: headbands, caps, surgical head covers and surgical helmets or hoods. Gloves are the main hand protection devices.		
Huh S ⁽³⁴⁾ 2020			Double gloves and protective clothing for the whole body, including shoes, KF94 equivalent mask and gloves (add safety glasses or face shield if necessary).
Wang H, Wang S, Yu K ⁽³⁵⁾ 2020			Training protocols on the use of masks, goggles, waterproof clothing and face shields.
Houghton C, et al. ⁽³⁶⁾ 2020	PPE (cloaks, gloves, masks, goggles) and hand hygiene.		
Verbeek JH, et al. ⁽³⁷⁾ 2020		Gloves, masks, goggles or face shields, long-sleeve cloaks and N95.	
Feroli M, et al. ⁽³⁸⁾ 2020	N95, glasses or face shield, long-sleeve water-resistant cloak and gloves. The use of N95 for a longer period is indicated in order to rationalize its use.	Respirator to be used (FFP2 European standard), when in contact with suspected and confirmed patients and in procedures with aerosol generation.	Use of the FFP2 respirator and bath after removing the PPE, disinfecting the ears and mouth.
Kowalski LPMD, et al. ⁽³⁹⁾ 2020			Guides on operating room with a negative pressure environment, ventilation system with a high efficiency particulate air filter. Use the coveralls with apron and goggles with face shield.
Zelaya S, et al. ⁽⁴⁰⁾ 2020			N95 or similar, PAPR, glove, cloak with long, disposable sleeves, in some cases recommends the use of protective clothing including sneakers, safety glasses or face shield.

Chart 2 – Characterization of studies published after the beginning of the COVID-19 pandemic according to: Authors; Year of publication; Recommendations from WHO, CDC or other. Ribeirão Preto, SP, Brazil, 2020

Recommendations regarding the use of PPE			
Authors/Year	WHO	CDC	Others
Brazil ⁽⁴¹⁾ 2020			Mask, apron, glasses and gloves; wear a surgical mask to assist the user with respiratory symptom. N95/FFP2 is indicated in procedures that can generate aerosols.
Paraguay ⁽⁴²⁾ 2020			Use of surgical mask, waterproof cloaks. The coveralls should be used according to the exposure risk category. The use of glasses and face shields when there is a risk of contact with secretions, in addition to N95 or similar. Reuse is not recommended, except in extreme needs.
Gallasch CH, et al. ⁽⁴³⁾ 2020			Recommends hand hygiene, use of goggles or face shield, surgical mask, waterproof apron and procedure gloves. The use of a cap and N95 or FFP2 are indicated during the performance of aerosol-generating procedures.

Chart 2 – Cont.
Source: Research data, 2020.

DISCUSSION

It was evidenced that the experiences with coronavirus (SARS-CoV and MERS-CoV) prior to the COVID-19 pandemic revealed important conducts to be taken in the prevention of occupational health risks, which reflected in influences in the use and standardization of PPE determined in the current pandemic.

From these experiences acquired after the first SARS-CoV outbreak in 2002, a study highlighted the importance of the work of a professional specialist in occupational health, in this case the nurse, to plan and develop health and safety actions for workers in the workplace in institutions in the midst of an epidemic outbreak⁽²¹⁾.

Since the first cases of coronavirus infection, precautionary measures by contact, droplet and aerosols have been encouraged by global health agencies that determined the demand for the use of PPE during the contact of health professionals with COVID-19 patients. The initial studies on coronavirus outbreaks made evident the effectiveness and the incentive to use, for example, the N95 mask (high-filtration respiratory protection mask).

As for the use of the N95, there was already evidence for the fact that this equipment became scarce during outbreaks or pandemics, even emphasizing the possibility of reuse. In this case, a procedure for safe and adequate reuse must be implemented, but still without strong scientific evidence about the time of reuse and validity of these masks.

In addition, the use of a loose barrier, such as a surgical mask or face shield over the N95 mask, and the need to label the equipment with the professional's name to avoid use by another person⁽²²⁾. Another highlighted aspect is the essential training of health professionals as for techniques of dressing and removing PPE, in order to avoid possible contamination.

Studies have also shown that in the period after the pandemic they added hair and head protection⁽³³⁾, water resistant cloaks⁽³⁸⁾ and the use of the N95 mask, or similar, for a longer period of time in order to rationalize its use⁽³⁸⁾ due to the scarcity of the product on the world market. With regard to the other guidelines, some countries have also included mouth and ear disinfection⁽³⁸⁾; operating room with a negative pressure environment and ventilation system with a high-efficiency particulate air filter⁽³⁹⁾.

Thus, through the past experiences and the pandemic experiences by COVID-19, it is not clear which type of PPE guarantees better protection, also the technical standards and their categorization make the use of this equipment complicated and confusing, in addition, knowledge about SARS-CoV-2 virus is still under development.

The identified recommendations before and during the pandemic are presented in the following topics: 1) use of surgical mask and N95 or similar and their reuse, double clothing and use of coveralls; 2) elaboration and practice of care protocols in providing care; and, 3) training or qualification of health professionals.

Regarding the use of masks, the types N95, FFP2 or similar are indicated during the realization of aerosol-generating procedures, such as intubation or tracheal aspiration, invasive and non-invasive mechanical ventilation, cardiopulmonary resuscitation, manual ventilation before intubation and nasopharyngeal sample collections^(2,10). Still, PPE is for single use and should not be reused, however, in extreme cases of scarcity, different approaches may be taken, such as the use of masks for up to three uses⁽⁴²⁾.

The use of N95 offers greater protection to the worker when compared to the surgical mask in the SARS-CoV-2 case^(11,28–29,33–34). Likewise, PAPR is 2.5 times higher in protection than N95⁽³³⁾, but this type of respirator is not usually recommended for the care of patients with COVID-19⁽⁴⁴⁾. WHO⁽¹⁰⁾ and CDC⁽⁴⁾ do not indicate masks made of cotton tissue by health professionals as another alternative to surgical masks or respirators, as there is no scientific evidence of appropriate protection.

The protection of the neck and even the head is not contained in the WHO guidelines⁽¹⁰⁾, but these exposed areas can serve as a source of contamination. Hooded coveralls can protect better than the cloak, however, there is little evidence that greater coverage on the body leads to better

protection and, in the process of undressing, can lead to possible contamination^(37,44). People who use the cloak are less likely to become contaminated and offer greater comfort to the worker because it is made with a more "breathable" material⁽³⁷⁾, in addition, preserving the integrity of the cloak on removal reduces the risk of contamination with the secretions present in the clothing⁽⁴⁴⁾, therefore, tearing the equipment for disposal is inappropriate.

Bathing after removing PPE can be positive for preventing contamination, but this practice needs to be investigated. Another item that serves as a barrier to the pathogen for reaching body surfaces are gloves; these should overlap the cloak sleeve enough to prevent exposure of the wrist during movement⁽⁴⁴⁾. Studies indicate that the use of double gloves has advantages in relation to piercing with needles or even in the disposal of sharps, still considering the risk of tearing, carrying out tests, even in cleaning dirty areas and during the realization of procedures that generate aerosols^(33–34,37,44). The use of double gloves can lead to less contamination compared to simple gloves, it is also possible to hygiene the gloves with quaternary ammonia or other bleach, with the exception of alcohol, with frequent change of the external gloves when dirty or torn^(37,45). The WHO⁽¹⁰⁾ and the National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária - ANVISA*)⁽²⁾ recommend the use of a pair of gloves to avoid waste, except in surgical procedures with a high risk of rupture, indicating the use of double gloves⁽¹⁰⁾.

In this way, it is recognized the importance of adequate equipment, use, unequipping and disposal of PPE in facing the pandemic COVID-19. However, there are barriers that interfere with the effectiveness of the use of PPE due to ambiguity of information, absence of international guidelines, non-standardized use protocols, inadequate sizes of protective devices and dubious quality of equipment^(36,39). It is also noteworthy that there are deficiencies in the use of PPE by health professionals due to a lack of training, which leads to contamination mainly during undressing⁽³⁷⁾. On the other hand, there is evidence that even when the protocols are followed, professionals infected by COVID-19 are still registered during the care or transport of patients⁽³⁴⁾.

It is considered that, in addition to the appropriate use of PPE, factors such as work organization, the establishment of a flow of people in the contaminated and clean environment, the use of techniques and protocols are essential for the protection of health professionals and patients in the hospital environment and can, when used together, prevent illness and death of these professionals.

Globally, among the problems faced regarding PPE are: quantitative and qualitative insufficiency of equipment, the reuse of PPE in developing countries, where economic

resources are scarce. In addition to the concern with disinfection techniques that are used to reuse equipment, as there is no scientific evidence to prove the safety of this practice.

Even without evidences of safety for use, there are those who defend the reuse of PPE, considering the minimization of waste, protection of the environment and use optimization in face of the current scarcity. The possibility of decontamination of surgical masks and N95 by boiling water steam for 2 hours, has been shown to be effective for complete inactivation of the coronavirus⁽⁴⁶⁾, as has been raised by the WHO⁽¹⁰⁾ with studies about mask reprocessing.

It is indicated that in order to minimize the pandemic effects, training offered to health personnel is of great importance. After the MERS-CoV, studies⁽³¹⁾ showed that a dedicated, trained and well-informed team on care protocols contributes to the relief of anxiety and fear that arise in emerging infectious diseases, especially when related to occupational protection in the workplace. This is directly related to the adequate training and qualification of health personnel, reinforced in other studies its importance, as well as the rules for coping with COVID-19 by the CDC^(4,21-22,25,29,44). The use of computer simulation and lectures with videos to put and remove PPE, and practical activities can have a better result than a traditional lecture⁽³⁷⁾.

It is reiterated that nursing professionals are on the front line, and are the basis for any response activity, both in occupational health⁽²¹⁾ and in the provision of care⁽³¹⁾. These professionals suffer from increased workload and stress, which can accumulate through intensive care for infected patients, frustration with death and a lack of information about the virus.

It is noticed that in some countries the lack of training of professionals in how and when PPE should be used, compromised the efficiency and effectiveness of the devices used. The high demand for infected patients in face of the limited installed capacity of the services, the small number of health professionals available and trained to attend the demand, the scarcity of supplies and PPE, the lack of efficient protocols and the unpreparedness of the government to establish coping and offering support has generated in some countries a health, economic and political crisis of disastrous proportions for the population, and especially for health professionals who perform their duties in the care and patient care with COVID-19, and are in a situation of occupational vulnerability for lack of resources and government support.

The limitations of this review are centered on the limited number of robust studies on the subject, given the timing of the pandemic set up associated with the time required for the execution of research protocols and production of

scientific knowledge. However, the dissemination of this synthesis is important because it is a current and necessary theme for planning preventive actions against the illness and death of health professionals working in the care of patients with COVID-19.

■ CONCLUSION

The personal protective equipment used does not follow global standardization according to type, quality and adequate provision during the COVID-19 pandemic, exposing these professionals to the risk of contamination. The use of masks (surgical, N95 and similar), hat, gloves, cloak, apron, goggles and face shield are recommended by international bodies, but the situational analysis allows adaptation to the reality of each country, such as the use of coveralls, double gloves and hoods.

The COVID-19 pandemic raised concerns about the compatibility of guidelines and recommendations about prevention and control of infections, with respiratory diseases, practices and behaviors of health professionals. Inequality of access to PPE is identified, as countries with greater economic power adopt broad strategies to face COVID-19, since health professionals use extra protective equipment, associated with high engineering technology and intervention protocols in working process. In contrast, countries with low economic power need to balance the limitation of resources with the attention to health and occupational safety of health professionals, thus causing both to be compromised in the process.

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