

Review article

Required Personal Protective Equipment for Prehospital Healthcare Provider in COVID-19 Pandemic: A Systematic Review

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SUMMARY

Aims. Coronavirus Disease 2019 (COVID-19) is a highly contagious disease, and a variety of personal protective equipment (PPE) has been recommended as preventive measures for prehospital emergency personnel, which has led to considerable challenges and a great confusion for the personnel. This review aims to identify different types of PPE required in the care of COVID-19 patients in prehospital emergency system.

Material and methods. This study was carried out by searching through databases including: Pubmed, Proquest, Google Scholar, and Cinahl. All articles that recommended different types of PPE against COVID-19 and infectious diseases for prehospital emergency personnel were collected in a table.

Results. After carrying out the initial search in the databases, 1,009 studies were obtained and then 16 articles were selected. The findings seem to suggest using equipment including: gloves, face shields (shield/goggles), protective clothes (medical jumpsuit/scrubs), surgical masks, N-95 masks, powered air purifying respirators (PAPR), hair covers, shoe covers and washing up the hands by the emergency medical service (EMS) personnel.

Discussion. The scrutiny of the relevant studies showed that each of them advised the EMS personnel to use a number of PPE. The present study highlighted the fact that there are other components of the PPE which can be useful to them.

Conclusion. This study identified the most appropriate PPE needed for prehospital emergency personnel against COVID-19, and it is believed that planning for adequate access to this equipment and training on how to use them can significantly help to reduce the infection among the personnel.

Keywords: COVID-19, emergency medical services, personal protective equipment, prehospital emergency

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INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is an emerging infectious disease which is highly contagious and is regarded to be an acute respiratory illness. This disease is caused by a new virus from the coronavirus family (1). It was first identified in Wuhan (China) in December 2019. The World Health Organization (WHO) declared that it was a global pandemic on March 11, 2020 (2). The spread of COVID-19 in the world has dramatically increased the load of prehospital emergency responsibilities which are related to respiratory distress (3, 4). A study in Venice (Italy) reported that the number of prehospital emergency missions which were carried out to transport the patients with respiratory distress to hospital had increased by 56% (3). Moreover, the results of a study in Sierra Leone showed that 64% of COVID-19 patients were transported to the hospital by the emergency medical service (EMS) (5). According to the report, the number of the above-mentioned missions had increased by 35% during the COVID-19 pandemic in Iran (6). This issue puts emergency medical personnel at serious risk of infectious agents (7). Consequently, the use of personal protective equipment (PPE) is part of the EMS standards of the provision of care to the patients who are suspected to have COVID-19 and is recommended by WHO (8).

PPE is the means acting as a barrier between the user and the microorganisms. It prevents the spread of microorganisms among the health care personnel (9). Different types of PPE are known to provide the health care personnel with various degrees of protection (10). Therefore, the EMS personnel must use all of the components of PPE in accordance with the standards when providing care for the patients or transporting them to hospital (11). The adequate access to PPE and its proper use can reduce the exposure of personnel to the disease and may enable them to provide higher-quality care (12). It can also hinder the spread of the disease to other members of the community, later patients, colleagues, and family members (13). The studies which were conducted in England in April 2020 showed that EMS personnel had inadequate access to PPE (14). As a result, many of them had to use the existing resources for a long period of time or were forced to reuse them, which can increase the risk of infection both for the personnel and other patients (15, 16). A study reported that 90% of patients with

COVID-19 may be asymptomatic or might display mild symptoms of the disease in prehospital emergency departments (17). Therefore, despite the widespread shortage of PPE, the EMS personnel must adhere to safety protocols on all of the missions (18). Paying due attention to PPE is one of the important strategies for controlling infections in all EMS systems (19), such that EMS has been allocated a budget of \$ 100 million by the United States government in order to purchase PPE (18). Similarly, in Sierra Leone, 25% of the EMS monthly budget is allocated to the provision of PPE (5). Considering the increase in the number of the infected health professionals and their high mortality rate worldwide (20), and the important role that PPE could play in stemming the tide of the disease, coupled with the uncertainty surrounding the time, type and method of using PPE which stems from the existence of different guidelines confusing the personnel what equipment to use on missions, the present study carried out a systematic review of all of the PPE studies which have been conducted in the prehospital emergency departments during the COVID-19 pandemic. The study intended to highlight the fact that the identification of the required PPE components and the EMS personnel members' proper use of these components can have a positive effect on the reduction of the prevalence of this disease.

This review was conducted to identify different types of PPE required in the care of COVID-19 patients in prehospital emergency system. The primary research question guiding this review was: what equipment is appropriate to protect personnel against COVID-19 virus? Identification and use of standard equipment can significantly help to reduce the infection among the personnel.

MATERIAL AND METHODS

This study was carried out by searching through a number of databases, including PubMed, MEDLINE, CINHALL and Google scholar, and by using certain keywords that involved: COVID-19, emergency medical services, personal protective equipment and prehospital emergency. We selected all of the articles which were about the PPE and the EMS personnel. Moreover, two people collected the articles which were related to the subject of the study and had been carried out by 2021. The Preferred Reporting Items for Systematic Reviews (PRISMA) was used to collect the data of the study. After car-

rying out the initial search, 1,009 studies were obtained.

Inclusion and exclusion criteria

The articles that met the inclusion criteria were those: 1) focusing on the PPE which is used against infectious diseases; 2) related to the pre-hospital emergency personnel; and 3) focusing on COVID-19 or acute respiratory diseases. On the other hand, the exclusion criteria for the articles included: 1) not focusing on PPE in the field of medicine; and 2) being unrelated to the EMS personnel. Such articles were excluded from the study by examining their titles and abstract sections.

Selection and extraction

After searching for the articles in all of the databases using the keywords, the article references were entered into ENDNOT to exclude duplicate ones. Next, the titles and abstract sections of the articles were examined, the articles which did not meet the inclusion criteria were excluded, and the full text articles which were related to PPE in EMS during the COVID-19 pandemic were selected. Then, the researchers excluded the articles which were not

related to the prehospital emergency or were similar to the other articles in terms of content. Moreover, they excluded the articles whose full text forms were not available. Finally, 16 articles were analyzed, and the protective equipment, which was recommended in these articles for the prehospital emergency personnel, was examined and the necessary protective equipment was thus extracted.

RESULTS

In this study, a total of 1,009 articles were retrieved by searching through the aforementioned databases. Next, 412 duplicate articles were identified and excluded. Then, the titles and the abstract sections of the remaining articles were examined, which left us with 60 articles. After that, 22 articles were excluded from the remaining articles due to the fact that they were not related to the prehospital emergency. Twelve more articles were excluded from our data since they were similar to the other articles in terms of content. In addition, 10 articles were dropped from consideration owing to the fact that their full text form was completely unavailable to the researchers (Figure 1). Finally, 16 articles were selected and were completely examined (Table 1).

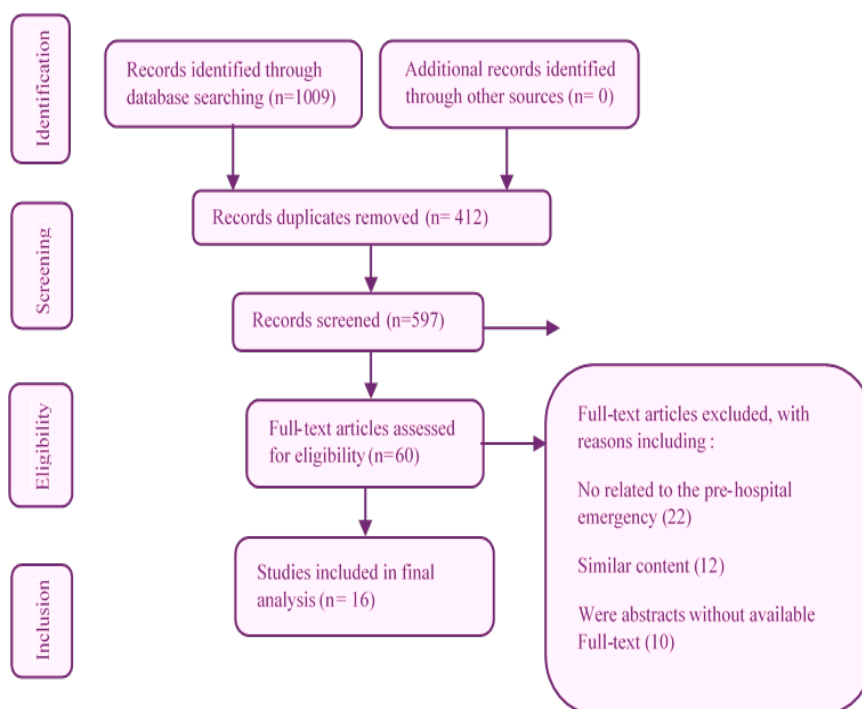


Figure 1. Flow diagram of study selection

Table 1. Descriptive summary of included studies

Title	Recommended PPE	Results	Conclusion
1) PPE Misuse and its Effect on Infectious Disease among EMS in Saudi Arabia (21) Alshammaria A (2019)	-Gloves -Surgical mask -Face shield -Surgical scrubs -Shoe cover -Hair cover -Hand disinfection	- In this study, 64% of personnel members did not wear scrubs despite the need to wear them and 83% of them took off these clothes in a non-standard way. - Moreover, 38% of personnel members did not use the face shields when they needed them and 41% of them did not remove them in a proper way.	- The EMS team did not pay attention to COVID-19 standards. - Disinfecting the environment, limiting contact with the patients, cleaning the ambulance, and taking measures to control the patients' source of secretions were not observed by the EMS team. - The medical team did not have sufficient knowledge about the prevention of infection and its control standards.
2) Personal Protective Equipment (PPE) Using in Antalya 112 Emergency Ambulance Services During Outbreak (24) Gulsen MF (2020)	-Gloves -N-95 mask or FFP2 -Eye protection goggles -Face shield -Scrubs -Hand disinfection	-Most of the personnel members used Level 4 PPE (N95 mask, goggles / face shield, gloves & scrubs) which is the general standard equipment for COVID-19 patients (Nafar, 1996). As a result, the exposure risk was very low for 84% of the personnel members.	- Timely provision of the required PPE, planning, considering different scenarios regarding the unexpected situations, and the employees' participation in the decision-making process were effective in controlling the spread of the disease to the personnel members and reducing their exposure to the disease.
3) Integration of Aeromedicine in the Response to the COVID-19 Pandemic (25) Osborn L (2020)	The recommended PPE for transporting the patients by helicopter: -Gloves - N-95 mask -Eye protection goggles -Face shield- -Disposable scrubs	-None of the personnel members developed the COVID-19 symptoms 14 days after 6 transfers of the patients with the disease.	- Training, strict adherence to standard PPE guidelines, and disinfection were the main methods of preventing the infection in EMS. - The EMS personnel members were advised to use surgical masks regardless of the diagnosis of COVID-19 due to the fact that the disease was prevalent in the community and since a number of people were asymptomatic or displayed unusual symptoms.
4) COVID-19 Personal Protective Equipment (PPE) for the Emergency Pysician (11) Holland M (2020)	-Two pairs of gloves -N-95 mask -Hand disinfection -The people who have beards or the people who cannot undergo the face-fit test in an appropriate way can use powered air purifying respirator (PAPR)	-The personnel members contaminated the clean wards since they did not pay attention to their hand hygiene and did not dispose of their used PPE before entering them.	- According to the results of this study, the EMS personnel members should use all of the components of PPE in accordance with the standards when they provide care to the patients and when they transport the patents to different places. Moreover, they should ask the patients to wear surgical masks.
5) COVID-19 Preliminary Case Series: Characteristics of EMS Encounters with Linked Hospital Diagnoses (26) Fernandez AR (2020)	-Gloves -Mask (surgery, N-95, PAPR) -Face shield / goggles	- In this study, 78% of the positive cases of COVID-19, which were diagnosed by the hospital, were suspected to have COVID-19. Moreover, the rate of the prognosis of EMS personnel members' disease was 20%. - In the case of patients who were suspected to have COVID-19, face shield, scrubs, N-95 mask, surgical mask and PARP were used in 84%, 69%, 73%, 16% and 7% of cases respectively.	- The results of the study showed that the EMS personnel members' suspicion in regard to the patients' diseases was not a good criterion for the use of PPE. Nonetheless, after identifying the patients with COVID-19-related symptoms at the prehospital stage, the EMS personnel members must use PPE to reduce the risk of their exposure to the disease.
6) Pre-hospital Infection Control Strategies during the Epidemic Period of COVID-19 (70) Hu P (2020)	-N-95 mask -Cap -Protective goggles -Scrubs or medical jumpsuit -Face shield	- The personnel used Class 2 PPE (N95 mask, cap, goggles, scrubs or medical jumpsuits, and face shields) when they provided care to patients. Moreover, the personnel members used Class 3 PPE (Class 2 PPE components + positive pressure head cover) when they performed aerosol-producing procedures.	- In order to prevent and control infection in pre-hospital emergency departments, a number of strategies should be developed based on: classification of patients and ambulances, classification of personnel members' PPE, disinfection and sterilization of ambulances, disinfection of the used medical equipment used, and disposal of medical waste.
7) Pre-hospital Assistance	-According to the	- A number of devices such as high	-Occupational hazards in prehospital

by Ambulance in the Context of Coronavirus Infections (27) Araujo AF (2020)	recommendations of WHO, EMS personnel should use standard PPE (surgical masks or N-95, N-99, N-100, Filtering Face Piece (FFP)2 or FFP3, medical jump suits, goggles and face shields, gloves and caps) - Disinfecting the hands with 70% alcohol should be done after providing care to patients.	efficiency particulate air (HEPA), which filter all of the bacteria and viruses should be used during the patients' mechanical ventilation. Nonetheless, access to these devices is limited.	emergency care are minimized during the COVID-19 pandemic by providing the personnel with professional training. All of the patients whose consciousness is decreased and the patients whose information is hard to obtain should be suspected of having COVID-19.
8)The Ethics of PPE and EMS in the COVID-19 Era (13) Maguire BJ (2020)	-The need to use personal equipment	-According to media reports in the US-British EMS system, the personnel had insufficient access to PPE in April 2020. Moreover, the replacement of equipment took weeks and PPE was not available to the personnel during this time period. As a result, the personnel members were at higher risk of COVID-19 due to their low ability to protect themselves against the disease.	- The lack of sufficient and standard PPE and the patients put the EMS personnel and the community at risk and had emotional and moral consequences for them. Is it ethical for the EMS personnel members not to provide care to the infected patients when they do not have adequate PPE? Or to expose subsequent patients to COVID-19 using non-standard equipment?
9) Defending the Front Lines during the COVID-19 Pandemic: Protecting our First Responders and Emergency Medical Service Personnel (18) Ehrlich H (2021)	- Research has shown that only 43.8% of COVID-19 patients may be symptomatic. Therefore, the EMS personnel should use PPE (N-95 mask, gloves, face shield, and medical jumpsuit) on all of the missions.	-Health screening before each shift and using PPE throughout the shift are essential and protect the personnel members against the diseases.	- In order to prevent the spread of infection in the EMS system, doing rapid tests for symptomatic personnel members, paying attention to personnel members' needs, having flexible programs, using stable protocols and equipment, reducing the number of personnel members who provide care to the patients, and having a standard return-to-work program are very effective.
10) EMS Disease Exposure, Transmission, and Prevention: A Review Article (16) Bitely C (2019)	- Washing the hands and using the PPE appropriately are the best ways to prevent COVID-19.	- Most of the personnel members do not pay attention to their hand hygiene and do not adhere to the principles of the disinfection of the environment and medical equipment.	- Achieving a sterile environment and maintaining a clean prehospital work environment are difficult due to the lack of time, lack of the allocated resources, inappropriate cleaning time, and presence of the staff who provide cleaning services (such as the staff members who work in hospital). The lack of sterility and the presence of drug-resistant microorganisms put both staff and other patients at risk. Consequently, the standard disinfection protocols should be used.
11) Rational Use of Personal Protective Equipment (Ppe) among Health Workers in Covid-19 Frontline (29) Adeleye OO (2020)	- The use of standard PPE	- The non-standard use of PPE was one of the most important factors that caused the spread of this virus to the personnel. The factors that affected the improper use of PPE during COVID-19 pandemic included: discomfort in the form of difficulty in breathing, high heat, unavailability of PPE, inadequate training and negligence in following the instructions on how to use PPE.	- It was recommended that the medical personnel receive education, have access to adequate resources, receive training with regard to the use of PPE, observe the safety tips and follow protection protocols.
12) Emergency Medical Services Resource Capacity and Competency amid COVID-19 in the United States: Preliminary Findings from a National	-Protective gloves - N-95 mask	- Based on the findings, 94% of the EMS personnel members stated that they had adequate access to protective gloves and 48% of them noted that they had adequate access to the N-95 masks. Most of the personnel members (31%) stated that	- The study showed that the resource capacity and the competence of EMS personnel members during the COVID-19 pandemic were not satisfactory. Moreover, the deficiencies in training and using the protocol were serious concerns for the general health of the EMS personnel

Survey (15) Gibson C (2020)		they used the N-95 masks for a week or more before replacing them with new masks. Finally, 16% of the personnel members suffered from injuries which were caused by PPE.	members. Therefore, it was essential to remedy the aforementioned deficiencies in order to reduce the personnel members' exposure to coronavirus and their infection.
13) Access and Use Experience of Personal Protective Equipment Among Frontline Healthcare Workers in Pakistan During the COVID-19 Emergency: A Cross-Sectional Study (22) Hakim M (2021)	- The need to provide the medical personnel with PPE and to train them to use it appropriately	- Most of the personnel members (71.74%) did not have access to PPE and used certain coping strategies. For instance, they reused the N-95 and surgical masks. - In this study, 312 (68.87%) of the participants believed that the risk of COVID-19 was high in their workplace. Moreover, the majority of participants (62.69%) took precautionary measures at home in order to protect their families against the disease.	- The results of this study showed that the healthcare workers in Pakistan had limited access to PPE and had insufficient information on its use. Therefore, providing the healthcare workers with PPE and training them to use it properly were essential to protect them and their families during the COVID-19 pandemic.
14) Occupational Exposures and Programmatic Response to COVID-19 Pandemic: An Emergency Medical Services Experience (12) Murphy DL (2020)	-Mask (surgery or N-95) -Gloves -Face shield -Scrubs	-The examination of PPE showed that in 66.9% of the cases, the mask, gloves, face shields and scrubs were widely used. In 29.3% of the cases only gloves and face shields were used. In 3.1% of the cases, there was a delay in using PPE. Finally, in 0.7% of cases, the use of PPE was not clear.	- Based on the results of this study, the risk reduction program strategies, personnel members' adequate access to PPE and their appropriate use of PPE reduced their occupational exposure to the disease.
15) Occupational Exposure to Infection Risk and Use of Personal Protective Equipment by Emergency Medical Personnel in the Republic of Korea (23) Oh HS (2016)	-Gloves -Masks -Eye protection goggles -Protective clothes -Face shields -Caps -Shoe covers	-How to use PPE when the medical personnel members transport the patients with symptoms of respiratory distress; - Mask, disposable gloves, sterile gloves, goggles, scrubs, face shields, and shoe covers were used in 93%, 58%, 39%, 25%, 11%, 10%, and 4% of cases respectively.	- The results of the study highlighted the fact that the standards were not fully met with regard to the use of PPE. Therefore, the personnel members were advised to receive education on the protocol and to use it in order to reduce their occupational exposure to the disease.
16) Use of Personal Protective Equipment during Infectious Disease Outbreak and Non-outbreak Conditions: A Survey of Emergency Medical Technicians (10) Visentin LM (2009)	- Insufficient knowledge of the use of PPE	- Lack of access to PPE, judgments about the necessity of PPE, and technical problems were the important reasons for not using PPE according to the instructions.	- Based on the results of this study, the EMS personnel members' knowledge about the requirements for the use of PPE was not completely compatible with the instructions of the management.

The examination of the relevant studies showed that they had advised the EMS personnel to use different types of PPE including gloves, face shields (shields/goggles), protective clothes (medical jumpsuits/scrubs), surgical masks, N-95 masks, powered air purifying respirators (PAPR), hair covers, shoe covers and to wash their hands.

Gloves

Viruses, including severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and COVID-19 remain on different

surfaces and infection can be transmitted through skin-to-skin contact with an infected person or by touching contaminated items from a person's room (11). As a result, gloves prevent the health care personnel from having direct contact with the virus and obstruct the spread of the disease to them (12, 21). Gloves have been one of the most commonly used tools to prevent health care providers and the general public's infection since the onset of the COVID-19 pandemic (22, 23). Most of the relevant articles (which were reviewed in this study) have emphasized the importance of the EMS personnel's use of gloves (11, 12, 18, 21, 23-27).

Face shields

The probability of EMS personnel's occupational exposure to patients' blood and body fluids is high (23). Moreover, the diseases may spread to them when the patients cough, sneeze and speak (27). That is, the contaminated droplets in the mucous membranes of the eyes, nose, and mouth can spread the diseases to the personnel (16). Considering these issues, the use of face shields (shields/goggles) is critical for the healthcare professionals (12, 26). COVID-19 is less prevalent among the personnel members who use face shields (12). Therefore, this study showed that the use of face shields and eye goggles can be useful to the EMS personnel (12, 18, 21, 23 - 25, 27, 28).

Protective clothes

Studies have shown that scrubs obstruct the spread of the coronaviruses to the personnel by preventing them from having direct contact with contaminated surfaces and patients' secretions (12, 18, 21, 23 - 25, 27, 28). They reduce the risk of the spread of the disease to medical personnel, to the environment and to other patients (11). Likewise, the Center for Disease Control (CDC) advises EMS personnel to use protective clothes when they provide care to the patients who are suspected to have COVID-19 (21). Consequently, the EMS personnel members must strictly observe the standards and wear and take off their protective clothes in an appropriate way (23).

Surgical masks

Surgical masks can filter up to 98% of bacteria and particles in the air whose lengths range from 0.1 to 5 microns (25). They do not fit on the whole face and cannot prevent the people from inhaling all of the airborne particles (11). Nonetheless, they dramatically reduce the spread of the diseases to the medical personnel (25). Notwithstanding, they should be replaced immediately when the person coughs or sneezes (11). Surgical masks have been one of the most commonly used tools to prevent the health care personnel and the general public's infection since the onset of this pandemic (22, 23, 25). Most of the examined studies have advised the EMS personnel to use surgical masks (12, 21 - 23, 25 - 27).

Similarly, CDC has advised the above-mentioned personnel to use the surgical masks in order to obstruct the spread of the large droplets (11). Consequently, the EMS personnel members are advised to use surgical masks when they transport the patients or when they provide care to the patients owing to the fact that the disease is prevalent in the community since a number of people are asymptomatic or display unusual symptoms (11, 25).

N-95 Masks

Respirators (filtered masks) cover the face completely, filter very small viral particles (0.5-0.02 microns) (10) and reduce the concentration of aerosol to one-tenth of the ambient air (29). Several respirators (N95-N99-N100, R95-R99-R100 and P95-P99-P100) have been classified according to the standards of the National Institute for Occupational Safety and Health (NIOSH) (11). Most of the studies have emphasized the importance of the medical personnel members' use of N-95 masks when they provide care to the COVID-19 patients (11, 12, 18, 25, 27, 30). Some of the studies have recommended the use of these masks only in aerosol-producing procedures such as cardiopulmonary resuscitation, intubation, extubation, tracheostomy, bronchoscopy, suction, and non-invasive ventilation among others due to the lack of equipment and the additional costs it can impose on the normal health care system (24, 26, 28). Similarly, WHO has advised the EMS personnel members to use N-95 masks or other similar masks when they provide care to the COVID-19 patients (11). The results of the studies have shown that the EMS personnel members who have used N-95 masks have not developed COVID-19, and that these masks have been quite effective in preventing the personnel from contracting the diseases (24).

PAPR

PAPR is a breathing mask with an air filter or cartridge that filters the polluted particles in the air by passing ambient air through the air purifying elements (11). These masks have a driving force and are more efficacious in comparison with the disposable masks due to their positive pressure. They completely protect the personnel against the pathogens (27). Moreover, they do not make breathing hard for the users, are more comfortable for the users, and can be reused. These masks are also suitable for

people with a beard (11). Furthermore, they are suitable for the people when the respirators do not fit on their face (26). These masks can be used when there is a shortage of N-95 masks (11). The studies have shown that the personnel members, who give chest massage, should use PAPR due to the possibility of the movement of the N-95 masks on their face and the existence of air leakage (26). Consequently, PAPR can be useful to the EMS personnel members due to the relatively unstable conditions of their workplace and their responsibility to frequently transport the patients to different places (11, 26, 28).

Shoe cover and hair cover

The contaminated secretions and the respiratory particles may settle on the medical personnel members' scalp, hair, and shoes during aerosol-producing procedures on the patients with COVID-19 (11). The virus is not able to infect those parts of the body. Nonetheless, the virus may enter the personnel members' eyes, nose, and mouth and may infect them when they touch the above-mentioned parts of their bodies (11, 16). The use of N-95 mask, face shield, scrubs, and gloves may not protect the EMS personnel completely (28). Therefore, the EMS personnel members are advised to cover all parts of their body especially the upper body in order to prevent the drip contact of the airborne particles and the spread of the disease to other personnel members (13, 22). In this regard, most of the relevant studies have emphasized the importance of the EMS personnel members' use of shoe covers and hair covers in addition to the other components of PPE (18, 21, 23, 24, 27, 28). However, the EMS personnel members have ignored the appropriate use of these covers despite all the recommendations (21, 29).

Washing and disinfecting hands

Hand washing is regarded to be the most important measure to prevent the spread of the diseases, obstructing the spread of infectious diseases (16, 21, 29). The examination of the pertinent studies showed that they had emphasized the observation of hand hygiene according to the standards in the form of regular hand washing with soap and water for at least 40 seconds and hand disinfection for 20 to 30 seconds using 70% alcohol in order to obstruct the spread of COVID-19 virus (21, 27), and to prevent the personnel members' infection and the contami-

nation of the clean areas in EMS (11). Moreover, the studies have shown that the infection rate of the personnel members who have regularly washed and disinfected their hands has been low (11, 21).

DISCUSSION

The present study is one of the few studies which has identified all of the components of PPE which are used to protect the prehospital emergency personnel against the COVID-19 disease, advising the EMS personnel members to wash up their hands and to use equipment such as gloves, face shields (shields/goggles), protective clothes (medical jumpsuits/scrubs), surgical masks, N-95 masks, powered air (PAPR), hair covers, shoe covers.

The results of the study highlighted the fact that gloves are one of the main components of EMS personnel members' standard PPE. Based on the results, the use of gloves is essential for the EMS personnel and is very effective in guarding against diseases. Similarly, Casanova et al. emphasized the importance of the medical personnel members' use of gloves when they provide care to COVID-19 patients and noted that the use of gloves had a significant effect on stemming the tide of the disease (31). Likewise, Holland et al. advised the EMS personnel members to use two pairs of gloves to protect themselves when they provided care to the patients (11). The studies have reported that 94.6% of the used gloves have been latex, nitrile and nylon. Nonetheless, vinyl gloves have been used less than the other types of gloves (32). The latex gloves are easy to use and provide adequate protection against pathogens (33). However, they may cause allergic reactions (32). The nitrile gloves are more suitable than the other types of gloves due to their lower costs, higher resistance to pathogens, and lower risk of allergies (34). In this regard, most of the medical centers have used nitrile gloves to prevent latex allergy (35). The increase in the spread of diseases and the environmental pollution has increased the use of protective gloves (36, 37). The excessive and prolonged use of gloves can be dangerous and may cause skin dermatitis (38). Therefore, it is recommended that the medical personnel use moisturizing creams and lotions to prevent their skin dermatitis (39).

Furthermore, our results showed that face shields and goggles obstruct the spread of the diseases to the EMS personnel and reduce the person-

nel members' occupational exposure to COVID-19 by preventing the contact of infected patients' secretions with the mucous membranes of their eyes, mouth and nose. The coronaviruses can be spread through the eye. Moreover, the researchers have highlighted the fact that goggles can reduce the risk of the viral infections by 5 times. Consequently, the use of face shields and goggles plays an important role in the prevention of the spread of the disease (39). In addition, Bischoff et al. stated that the use of face shields prevents 90% of coronavirus transmission (40).

The results of the study showed that the protective clothes are one of the main components of PPE and can be used to protect the EMS personnel against COVID-19 due to the fact that they reduce the risk of the spread of the diseases to them by preventing them from having contact with contaminated surfaces. In this regard, the study of Seto et al. showed that the medical personnel members' protective clothes had a significant effect on the prevention of the transmission of disease to them (41). Similarly, Mehta et al. stated that in addition to the use of protective clothes, the personnel members needed to use plastic covers on the patients' bodies or small glass chambers above the patients' heads during intubation in order to minimize their contact with the patients' secretions and to protect themselves during CPR (42). Weissman argued that the use of the shoe covers and hair covers is essential for the medical personnel due to the fact that the protective clothes and other pieces of equipment may not completely protect them against the disease (43). Likewise, Brewster emphasized the fact that the medical personnel members had to completely cover their body and use shoe covers and hair covers in order to prevent the airborne and polluted particles from having contact with them (44) and transmitting the disease to them (45).

Moreover, based on the results of the present study, the surgical mask is an important piece of the EMS personnel members' PPE and prevents them from inhaling the airborne contaminants (46, 47). Similarly, the results of the study by Ng et al. showed that the surgical mask significantly reduced the spread of the disease to the medical personnel (48). Wen noted that the surgical masks provided the medical personnel with little protection against the respiratory infections and stated that the personnel members should use them when they do not have access to the N-95 masks (49). Similarly, Chughtai et

al. pointed out that the surgical masks could be used in the low-risk environments (50). A number of other studies have argued that surgical masks and N-95 masks have a similar effect on the prevention of COVID-19 in clinical conditions (46, 51, 52). Nonetheless, N-95 masks are preferred to the surgical masks when the aim of their use is to prevent the personnel from getting infected (53). Therefore, the EMS personnel members are advised to use surgical masks and to ask the patients to use these masks when they transport the patients to different places or when they provide care to the patients owing to the fact that the disease is prevalent in the community and since a number of people are asymptomatic (25).

On the basis of our results, the use of N-95 masks that filter very fine particles (54, 55) is preferable when the aim of their use is to prevent the respiratory spread of COVID-19 to the EMS personnel members. These masks are disposable and can be used for a maximum of 8 hours (56). Nonetheless, in certain conditions, they can be used anew when the medical personnel wear surgical masks or face shields on them (57). They are more useful to the EMS personnel members when they are on missions and can be intermittently used for 5 times or for 5 days (58). Notwithstanding, they should be replaced regardless of their duration of use when they are obviously contaminated, lose their shape, or are not fixed on the face (59). Maltezou et al. advised the personnel members to use N-95 masks when they performed aerosol-generating procedures (60). Similarly, Tam noted that the medical personnel, who had adequate access to PPE, should use the N-95 masks when they provided care to all of the patients (61). A number of other studies have emphasized the importance of the medical personnel members' use of these masks since they are effective in preventing them from developing the diseases which are caused by coronaviruses (62, 63). PAPR was among the components of the recommended equipment of the present study. The results of the study by Michaels and Wagner highlighted the fact that this piece of equipment completely filtered the viral agents and provided the healthcare personnel with complete protection (63). Likewise, the results of the study by Suen showed that PAPR was more effective than the surgical and N-95 masks. Based on these results, the personnel members were advised to use PAPR when they provided care to the patients (56). On the basis of Australian protocol, the medical

personnel members have to use PAPR when they perform aerosol-generating procedures (64).

Hand hygiene has always been one of the most important factors in the control of infection. Likewise, it was one of the recommended components of PPE in the present study. CDC has emphasized the importance of the regular hand washing and hand disinfection and has stated that they break the transmission chain of the disease among the members of the public (65). WHO has noted that the five standard time periods of hand washing and hand disinfection include: before touching the patients, before carrying out any interventions, after having contact with body fluids, after touching the patients, and after touching the patients' surroundings (66). The results of the study by Kantor et al. highlighted the fact that hand washing reduced the spread of infectious diseases by 24% to 31% (67). Likewise, based on the results of the study by Lan, appropriate hand hygiene significantly reduced medical personnel members' risk of COVID-19 infection (68). WHO has advised the EMS personnel members to pay attention to their hand hygiene when they provide care to the patients with COVID-19 and has stated that they should disinfect the frequently touched surfaces of ambulances at least three times a day (65). Based on the results of the relevant studies, 70% ethanol, 0.5% hydrogen peroxide and 0.1% sodium hypochlorite can be used to disinfect the above-mentioned surfaces of the ambulance (69).

Limitations of the study

There are several limitations in this study: our review included only studies published in English language that may have missed reports published in other languages, and despite a wide search strategy, relevant publications may have been missed. Also, considering that COVID-19 is a relatively unknown virus with successive mutations, and new information is discovered every day, it is suggested that research in this area be repeated and expanded.

CONCLUSION

The examination of the protective equipment which is used in the EMS underlined the fact that

different pieces of equipment are used on the expedition missions. The scrutiny of the relevant studies showed that they advised the EMS personnel to use a number of PPE such as gloves, N-95 masks, face shields and scrubs among others. The present study highlighted the fact that there are other components of the PPE which can be useful to the EMS personnel. The prehospital emergency personnel are the front line healthcare worker against COVID-19. There has been a significant increase in the personnel members' workload. Moreover, usually the ventilation of the ambulance cabin is poor when the personnel provide care to the patients. Considering these issues, it is clear that the prehospital emergency personnel must wear their protective clothes and should dispose of them in an appropriate way. Consequently, it can be argued that, in addition to the use of the aforementioned pieces of protective equipment, it is essential for the personnel members to use surgical masks, PAPR, hair covers, and shoe covers and to wash their hands properly.

The purpose of using all of these pieces of equipment is to prevent the personnel members from developing the COVID-19 disease. A number of these pieces of equipment may be more useful to the personnel members in comparison with the others. PAPR is the most useful piece of protective equipment during cardiopulmonary resuscitation (CPR) when the personnel members have beards or when the N-95 masks are not fixed on their faces. Similarly, the surgical masks and face shields reduce personnel members' exposure to the disease and increase the time period in which the N-95 masks can be used. Consequently, all of the patients must wear them when they are transported to different places. The polluted airborne particles may settle on the personnel members' clothes when they perform aerosol-generating procedures and can expedite the spread of the disease. Considering this issue, the medical personnel members are advised to wear scrubs and use hair covers and shoe covers. Likewise, washing hands is regarded to be the most important preventive measure which is taken to obstruct the spread of the disease to medical personnel members. Therefore, it is essential for the personnel members to wash their hands before and after touching the patients and their surroundings.

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Potrebna lična zaštitna oprema za pružaoce prehospitalne zdravstvene zaštite u pandemiji kovida 19: sistematski pregled

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SAŽETAK

Cilj. Kovid 19 je veoma zarazna bolest, a kao preventivna mera osoblju hitne medicinske pomoći preporučuje se različita lična zaštitna oprema, što je dovelo do značajnih izazova i velike konfuzije kod osoblja. Ovaj pregled ima za cilj da identifikuje različite vrste lične zaštitne opreme potrebne za zbrinjavanje pacijenata sa kovikom 19 u predbolničkom sistemu hitne pomoći.

Materijal i metode: Ova studija je sprovedena pretraživanjem baza podataka uključujući *Pubmed*, *Proquest*, *Google Scholar* i *Cinahl*. Svi članci koji su preporučivali različite vrste lične zaštitne opreme protiv kovida 19 i zaraznih bolesti predbolničkom osoblju hitne medicinske pomoći prikazani su u tabeli.

Rezultati: Nakon inicijalne pretrage u bazama podataka dobijeno je 1009 studija, a zatim je odabrano 16 radova. Rezultati ukazuju na korišćenje sledeće opreme: rukavice, štitnici za lice (štit/naočare), zaštitna odeća (medicinski kombinezon/uniforma), hirurške maske, maske N95, respiratori za prečišćavanje vazduha, štitnici za kosu, navlake za cipele i pranje ruku od strane osoblja hitne medicinske pomoći.

Diskusija: Ispitivanje relevantnih studija pokazalo je da je svaka od njih preporučivala da osoblje hitne medicinske pomoći upotrebljava ličnu zaštitnu opremu. Ova studija je istakla činjenicu da postoje i druge komponente lične zaštitne opreme koja može biti od koristi.

Zaključak: Ova studija je identifikovala najprikladniju ličnu zaštitnu opremu koja je potrebna predbolničkom osoblju hitne medicinske pomoći u borbi protiv kovida 19, a smatra se da planiranje adekvatnog pristupa ovoj opremi i obuka o njenom korišćenju mogu značajno pomoći u smanjenju zaraze među osobljem.

Ključne reči: kovid 19, hitna medicinska pomoć, lična zaštitna oprema, predbolnička hitna medicinska pomoć