Title: Exposure Risk Assessment and Risk Management of Pre-Hospital Paramedics During COVID-19 Pandemic

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Abstract

Background: Pre-hospital paramedics providing immediate care to patients with contagious disease were at high risk of infection. This study aimed to assess the exposure risk and risk management of pre-hospital paramedics during the COVID-19 pandemic.

Materials and Methods: A cross-sectional study was conducted among 335 paramedics from 49 emergency medical stations in two cities located in northwestern of Iran who were recruited through census. Data was collected using a World Health Organization questionnaire to assess the COVID-19 exposure risk of health workers.

Results: The results showed that the highest risk of exposure (86.0%) was in the domain of occupational exposure and that 55.2% of paramedics were at high risk of exposure to COVID-19. Among paramedics, 95.2% used personal protective equipment when caring for patient and 93.1% when performing aerosol-generating procedures.

Discussion: The results of this study highlight that pre-hospital paramedics have a high exposure risk in designated COVID-19 missions, while this exposure is reduced through infection prevention measures.

Conclusion: A significant number of pre-hospital paramedics were found to be at high exposure risk to COVID-19 during ambulance missions. Therefore, adherence to contact and droplet precautions, taking airborne precautions during aerosol-generating procedures, access to appropriate PPE, proper use of PPE, and appropriate training courses may lead to exposure risk management and improve their safety.

Keywords: COVID-19, Emergency, Occupational Exposure, Paramedic

Introduction

Pre-hospital emergency medical technicians or paramedics provide medical care in diverse, unique, uncontrolled, and dangerous environments (1). Accordingly, they encounter numerous infectious patients with unknown histories who require urgent treatment, which may expose them to infectious diseases (2). Because of caring for patients and providing emergency care such as cardiopulmonary resuscitation (CPR), suctioning and intubation, paramedics are at high risk of infectious diseases (3). Therefore, paramedics risk management and safety is an important issue in emergency management.

Exposure risk is defined as contact with a suspected or infected COVID-19 patient without the use of standard personal protective equipment (PPE) components by pre-hospital paramedics (4), and risk management involves the activities undertaken to reduce exposure to COVID-19 disease (5).

During the recent COVID-19 pandemic crisis, pre-hospital paramedics were the first healthcare providers for patients and played an essential role in health outcomes (6). They were put at great risk to save patients' lives (7, 8). In a 2020 study by Ashinyo et al., in Ghana, 80.4% of pre-hospital personnel were at high COVID-19 exposure risk (9), and this rate was 32.7% in another study from Korea (10). As an emerging and contagious disease, the COVID-19 pandemic poses a major challenge for pre-hospital paramedics that requires strict adherence to protocols (11). During this time, emergency medical service (EMS) dispatch missions worldwide increased dramatically. Because paramedics encountered many infected patients, they were at higher risk of illness, and an unprecedented workload was imposed on them (6, 7, 12-15). Study results showed that during this period, the number of missions to transport patients with acute respiratory distress syndrome and CPR increased by 56% and 58%, respectively (13-16). To avoid infection, paramedics should strictly follow protocols and guidelines and use personal protective equipment (PPE) (17). They should take advantage of PPE to comply with standards when transporting or caring for patients with COVID-19 (17, 18). The use of PPE was part of EMS standards when dealing with COVID-19 patients, which was recommended by WHO (19). PPE offers different levels of protection depending on the nature of its components, which include gloves, face masks, N95 masks, face shields, protective clothing, etc. (20). Adequate access to PPE components as well as their proper and principled use reduces the risk of paramedics' occupational exposure to the disease (6). Lack of access to this equipment and absence of knowledge and training can cause irreparable harm to paramedics (21). Subsequently, it is important to evaluate and manage the risk ratio among paramedics during the COVID-19 pandemic (22). The provided information can help improve paramedic safety during emerging diseases and pandemic crises.

According to Iran EMS system report, during the recent COVID-19 pandemic, daily calls to emergency medical care unit escalated unprecedentedly and the number of missions increased by 35%, with 10-20% of daily missions dedicated to patients who were suspected or infected with COVID-19 (7). However, the exposure risk rate, level of risk management and safety of paramedics are not known in most cities of Iran. The aim of this study was to assess the exposure risk and risk management of paramedics during the COVID-19 pandemic in Tabriz and Urmia cities in Iran.

Materials and Methods

Design and samples

This descriptive, cross-sectional study was conducted between March and May 2021. Data was collected from 49 rescue stations serving the metropolitan regions of Urmia and Tabriz located in northwestern of Iran with a total population of approximately 3,200,000 residents. In these regions, over 700,000 emergency calls are received by emergency medical centers annually, of which more than 150,000 result in emergency operations requiring the use of ambulances. The COVID-19 outbreak led to a sharp increase in the number of emergency calls and medical transports.

In this study, sampling was done by census, the sample size was equal to the population size, and all 335 pre-hospital paramedics employed in 49 emergency medical stations were selected. Inclusion criteria were at least six months of work record and previous experience of caring for at least one patient with suspected or confirmed COVID-19 disease in the pre-hospital setting. Employees who work part-time or in hospital emergency departments were not included in the study. Based on exclusion criterion, questionnaires with more than 10% incomplete or missing responses were excluded from analysis.

Data collection and tools

The data collection tools consisted of two questionnaires. The first questionnaire covered demographic and professional characteristics such as age, marital status, highest level of qualification, history of COVID-19 infection (you and your family), work experience, hours of work per week, place of work, field of education, average number of missions, average number infected patients with COVID-19 and median duration of contact with each patient.

The second questionnaire was adapted from a questionnaire developed by WHO to assess the risk and management of exposure to COVID-19. This tool is intended for healthcare facilities working with COVID-19 patients; it helps assess the risk to healthcare workers (HCWs) after exposure and

provides recommendations for their management (23). The questionnaire consists of three domains: community exposure to the COVID-19 virus (2 items with yes/no response), occupational exposure to the COVID-19 virus (6 items with yes/no response), and adherence to infection prevention and control measures when in contact with suspected or infected COVID-19 patients (22 items with four-point Likert scale response). This questionnaire assesses the type of activity in which HCW is involved. In addition, it measures the level of risk based on low or high-risk events. If an HCW answers "yes" on a community and occupational exposure subscale to any of the activities reported in the scale, the individual is considered to be at high risk of exposure to the COVID-19 virus. If an HCW selected the "always as recommended" response to any of the IPC measures when caring for a confirmed COVID-19 patient, the individual was considered to be at low risk of COVID-19 infection. If an HCW responds to other options, the individual is assessed as being at high risk for infection with the COVID-19 virus (9, 24, 25).

To calculate the overall exposure risk score, one point was assigned to high-risk items and zero points to low-risk items, and the sum of overall scores of the questionnaire items was considered as the person's total exposure risk score (score range = 0-30). Finally, considering the score of 50%, values ≥15 were considered high risk of exposure to COVID-19 and those <15 were considered low risk of exposure (9).

In the present study, the questionnaires were first translated into Persian by a professional translator and then translated back into English by another professional translator. The translators and researchers evaluated all versions of the questionnaires, and the final Persian version of the questionnaires was developed and approved through consensus after finding good agreement for all items. For content validity, the Persian version was given to 10 professors of Tabriz Faculty of Nursing and Midwifery and their suggestions were taken into account, and face validity was done based on interviews with 10 pre-hospital paramedics. The reliability of the scale was assessed using Cronbach's alpha coefficient in a pilot study with 30 pre-hospital paramedics ($\alpha = 0.89$). These paramedics were not included in the research sample. To collect data, the questionnaires were administered online via Porsline (https://survey.porsline.ir), namely an online survey tool widely used in Iran. In coordination with the emergency services, contact information for paramedics was collected and the link to the questionnaires was distributed to participants via e-mail and social media, including X (WhatsApp), Telegram, and Short Message Service (SMS). To maximize response rates, three reminder messages were sent over a two-month period. The response rate for the questionnaires was 90%. This methodology enabled the collection of a large dataset on practical experiences of paramedics in treating COVID-19 patients in the pre-hospital setting.

Statistical analysis

The collected data were analyzed using descriptive and inferential statistics such as chi-square, Fisher's exact test, as well as univariate and multivariate linear regression using SPSS software (version 21).

Ethics approval and consent to participate

This study was approved by regional research ethics committee of Tabriz University of Medical Sciences (IR. TBZMED.REC.1399.1079). To collect the data, the necessary coordination was also done with the responsible authorities. At the beginning of the questionnaire, there was a question about consent to participate in the study. While the necessary explanations were given to the paramedics, their informed consent to participate in the study was obtained. The principle of data confidentiality was respected by the researchers.

Results

In this study, all participating pre-hospital paramedics were male with a mean age of 32.81 ± 6.81 years. Their mean work experience was 8.41±6.15 years. Over two thirds (68.7%) of paramedics were married. Pre-hospital paramedics reported being in close contact with COVID-19 patients while providing care services, with an average of 30 minutes of contact with each patient during emergency missions. Tables 1 and 2 provide further details on demographic features of participants.

Insert Table 1-2

Table 1. Demographic characteristics of paramedics (N = 335)

Variables	Sub-group	Number (%)
Age	35 ≥	239 (71.3)
	> 35	96 (28.7)
	Mean ± Standard deviation	32.81±6.81
Marital status	Single	95 (28.4)
	Married	230 (68.7)
	Divorced	10 (3)
Highest level of qualification	Diploma and under diploma	16 (4.8)
	Associated degree	115 (34.3)
	Bachelor	186 (55.5)
	Master of Science	12 (3.6)
	Ph.D.	6 (1.8)
COVID-19 history	Yes	202 (60.3)
	No	133 (39.7)
COVID-19 history in family members	Yes	216 (64.7)
	No	118 (35.3)

Table 2. Occupational characteristics of paramedics (N = 335)		
Variable	Sub-group	Number (%)
Work experience (years)	≤10	225 (67.2)
	>10	110 (32.8)
	Mean ± SD	8.41±6.15
Work place	Urban emergency station	204 (60.9)
	Non-urban emergency station	74 (22.1)
	Urban and Non-urban emergency station	54 (16.1)
	Aerial emergency station	3 (0.9)
Field of education	EMT	236 (70.4)
	Nursing	64 (19.1)
	Anesthesia	11 (3.3)
	Operating room	2 (0.6)
	Other	22 (6.6)
Training on COVID-19	Yes	288 (86)
	No	47 (14)
Working hours per week in EMS	48	72 (21.5)
	72	147 (43.9)
	96	89 (26.6)
	Over 96	27 (8.1)
Average number of missions in a 24-hour shift	1-5	124 (37)
	6-10	82 (24.5)
	11-15	50 (14.9)
	16-20	63 (18.8)
	≤20	16 (4.8)
Average number of suspected patients	3>	151 (45.5)
	3-5	96 (28.7)
	6-10	78 (23.3)
	10<	10 (3)
Mean duration of contact with each COVID-19 patient	15 min	56 (16.7)
	30 min	104 (31)
	45 min	85 (25.4)
	1 h	63 (18.8)
	Over 1 h	27 (8.1)

EMS: Emergency Medical Service
EMT: Emergency Medical Technician

Regarding exposure to COVID-19, 93.4% of paramedics had a history of indoor contact with COVID-19 patients. Tables 3-5 provide further details on participants' exposure risk to COVID-19 and risk management.

Insert Tables 3-5

Table 3. Paramedics exposure risk to COVID-19 (N = 335)					
Domains	Items	Risk level		Number (%)	p*
Community exposure	History of being with COVID-19 patients in a common place	Yes		313 (93.4)	<0.001
		No		22 (6.6)	
	History of traveling with a COVID-19 patient with a distance of 1 meter from each other	Yes		239 (71.3)	
		No		96 (28.7)	
Occupational exposure	Direct care of a COVID-19 patient	Yes		306 (91.3)	<0.001
		No		10 (3)	
		Unclear		19 (5.7)	
	Face-to-face contact with a COVID-19 patient	Yes		300 (89.6)	<0.001
		No		15 (4.4)	
		Unclear		20 (6)	
	Medical interventions on the COVID-19 patient during AGPs	Yes		235 (70.1)	<0.001
		No		52 (15.5)	
		Unclear		48 (14.4)	
	Presence/ performing at the patient beside during AGPs	intubation	Yes	178 (53.1)	0.275
			No	157 (46.9)	
		Nebulizer treatment	Yes	62 (46.9)	<0.001
			No	273 (81.5)	
		Collecting sputum samples	Yes	32 (9.6)	<0.001
			No	303 (90.4)	
		Suction	Yes	130 (38.8)	<0.001
			No	205 (61.2)	
		Tracheotomy	Yes	17 (5.1)	<0.001
			No	318 (94.9)	
		Bronchoscopy	Yes	21 (6.3)	<0.001
			No	314 (93.7)	
		CPR	Yes	204 (60.9)	<0.001
			No	131 (39.1)	
		Other	Yes	72 (21.5)	<0.001
			no	236 (78.5)	
* Chi-square test					

CPR: Cardiopulmonary Resuscitation
AGP: Aerosol-Generating Procedure

Table 4. Paramedics adherence to infection prevention and control measures during patient care (N = 335)

Items	Risk level	Number (%)	p*
Using PPE during care of COVID-19 patients	Yes	319 (95.2)	<0.001
	No	16 (4.8)	
Gloves	Low risk	183 (54.6)	<0.001
	High risk	152 (45.4)	
Mask	Low risk	221 (66)	<0.001
	High risk	114 (34)	
Face shield	Low risk	63 (18.8)	<0.001
	High risk	272 (81.2)	
Gown	Low risk	63 (18.8)	<0.001
	High risk	272 (81.2)	
Removing and replacing PPE	Low risk	195 (58.2)	0.003
	High risk	140 (41.8)	
Hand hygiene before and after touching the COVID-19 patient	Low risk	208 (62.1)	<0.001
	High risk	127 (37.9)	
Hand hygiene before and after any clean or aseptic procedure on a COVID-19 patient	Low risk	208 (62.1)	<0.001
	High risk	127 (37.9)	
Hand hygiene before and after contact with body fluids of COVID-19 patient	Low risk	247 (73.7)	<0.001
	High risk	88 (26.3)	
Hand hygiene even with gloves after touching COVID-19 patient's surroundings	Low risk	227 (67.8)	<0.001
	High risk	108 (32.2)	
Regularly disinfecting frequently-touched surfaces (at least three times a day)	Low risk	125 (37.3)	<0.001
	High risk	210 (62.7)	
* Chi-square test			

PPE: Personal Protective Equipment

Table 5. Paramedics adherence to infection prevention and control measures during aerosol-generating procedures (N = 335)

Items	Risk level	Number (%)	p*
Using PPE during AGPs for COVID-19 patients	Yes	312 (93.1)	<0.001
	No	23 (6.9)	
Gloves	Low risk	210 (62.7)	<0.001
	High risk	125 (37.3)	
N-95 mask	Low risk	190 (56.7)	<0.001
	High risk	145 (43.3)	
Face shield	Low risk	63 (18.8)	<0.001
	High risk	272 (81.2)	
Gown	Low risk	80 (23.9)	<0.001
	High risk	255 (76.1)	
Apron	High risk	29 (8.7)	<0.001
	Low risk	306 (94.3)	
Removing and replacing PPE after AGPs	Low risk	193 (57.6)	0.006
	High risk	142 (42.4)	
Hand hygiene even with gloves before and after touching the COVID-19 patient during AGPs	Low risk	215 (64.2)	<0.001
	High risk	120 (35.8)	
Hand hygiene before and after AGPs for COVID-19 patient	Low risk	226 (67.5)	<0.001
	High risk	109 (32.5)	
Hand hygiene even with gloves after touching COVID-19 patient's surroundings during AGPs	Low risk	227 (67.8)	<0.001
	High risk	108 (32.2)	
Regularly disinfecting frequently-touched surfaces (at least three times a day) during AGPs	Low risk	139 (41.5)	0.002
	High risk	196 (58.5)	

* Chi-square test

AGP: Aerosol-Generating Procedure

In terms of exposure risk rate, the highest exposure risk (86.0%) was found in the domain of occupational exposure and in general, 55.2% of paramedics were at high risk of exposure to COVID-19. Tables 6-7 provide further details on paramedics' exposure risk rates and regression analyses.

Insert Table 6 -7

Table 6. Distribution of COVID-19 exposure risk for paramedics			
Domains	Risk level	Number (%)	p*
Community exposure	Low risk	105 (31.3)	<0.001
	High risk	230 (68.7)	
Occupational exposure	Low risk	47 (14)	<0.001
	High risk	288 (86)	
Adherence to infection prevention measures	Low risk	203 (606)	<0.001
	High risk	132 (39.4)	
Total score of exposure risk	Low risk	150 (44.8)	0.063
	High risk	185 (55.2)	
* Chi-square test			

Table 7. Univariate and multivariate linear regression between socio-demographic features and the exposure risk of COVID-19 among pre-hospital paramedics

Variable	Sub-group	Univariate		Multivariate	
		β (CI: 95%)	p-value	β (CI: 95%)	p-value
Highest level of qualification	Bachelor	Reference			
	High school diploma or under diploma	12.28 (2.54-22.02)	0.014	6.41 (-5.69-18.51)	0.298
	Associate degree	0.521 (-3.91-4.96)	0.818	1.17 (-3.51-5.86)	0.622
	Master of Science	6.82 (-4.31-17.96)	0.229	8.98 (-2.05-19.99)	0.110
	Ph.D.	18.32 (2.80-23.82)	0.021	17.82 (0.711-34.94)	0.041
Field of education	EMT	Reference			
	Nursing	1.88 (-3.39-7.16)	0.483	0.556 (-5.02-6.13)	0.845
	Anesthesia	-1.33 (-12.87-10.21)	0.821	-0.841 (-12.35-10.67)	0.886
	Operating room	19.99 (-6.59-46.56)	0.140	20.12 (-6.02-46.27)	0.131
	Other	12.93 (4.59-21.28)	0.002	7.86 (-2.77-18.50)	0.147
COVID-19 history in family members	No	Reference			
	Yes	5.48 (1.20-9.76)	0.012	5.65 (1.38-9.92)	0.010
Access to IV line	Yes	Reference			
	No	-5.26 (-10.24-0.274)	0.039	-7.11 (-12.11 to - 2.12	0.005

Discussion

The results of this study showed that most pre-hospital paramedics were at high risk of exposure to COVID-19, and the highest risk of exposure was found in the domain of occupational exposure. Some paramedics and their families contracted COVID-19. Consistent with the present study, other investigations concluded that healthcare workers had high rates of exposure to COVID-19 (9, 10, 26, 27).

These results are also consistent with reports of previous epidemics such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) (20, 28).

The high risk of exposure to a contagious disease such as COVID-19 should be managed appropriately as it could lead to infection as well as psychological effects such as burnout, reduced job satisfaction, intention to leave the job, etc. The results of a study showed that burnout was high among those who cared for long-term infected patients and among those who had a history of COVID-19 (29). In this regard, Lee and Kim (2020) emphasized that relevant organizations and managers must further focus on preventive measures in the workplace to control the pandemic (10). Since pre-hospital paramedics are at the forefront of the emergency response to pandemic (6) and are at high risk of exposure in the workplace, it is recommended that they should be properly trained and fully comply with infection control standards (20, 30).

In the present study, most paramedics adhered to infection prevention measures and used personal protective equipment when caring for patients and performing aerosol-generating procedures, which may lead to appropriate exposure risk management and improvement in their safety. While the results of some other studies indicated that compliance with infection prevention measures and the use of personal protective equipment by pre-hospital paramedics is challenging (1, 17).

Gulsen et al. reported a low prevalence of COVID-19 among pre-hospital emergency personnel in Turkey. They explained that timely provision of necessary PPE, regular work programs, planning multiple scenarios for unexpected situations, and involving staff in decision-making are effective in controlling the disease and reducing exposure among them (19). Murphy et al. (2020) reported that to reduce occupational exposure in pre-hospital paramedics, the implementation of risk reduction strategies and adequate access to PPE, as well as principled and proper application of it, are the most useful measures (31).

In this study, the risk of exposure to COVID-19 was higher among staff who provided more intensive medical care to the infected patients. Given that prolonged contact with infected individuals increases the risk of illness (1), paramedics must use standard PPE and decrease the time allotted to such patients as much as possible to improve their safety (1, 32).

Limitations

This study relied on self-reported questionnaires to collect data and evaluate paramedics' performance. Therefore, there may be a recall bias. Furthermore, the research was only conducted in the cities of Tabriz and Urmia in Iran, which limits transferability to other regions of the country. Future studies using objective performance metrics across a larger geographic area would strengthen conclusions regarding paramedics' competencies at a national level. In addition, the assessment was limited to the personnel of pre-hospital emergency service. Comparative analyzes of pre-hospital and hospital-based findings could provide valuable insights to optimize the continuity of care for patients with COVID-19. Another limitation of our study was online data collection, as a result of which the accuracy and authenticity of the subjects may be different from a field survey.

Conclusions

Pre-hospital paramedics were at high risk of exposure to COVID-19, and the highest risk of exposure was found in the domain of occupational exposure. Hence, staff training, adequate access to PPE and training on its use, adherence to standards in implementing protective protocols, minimizing the length of stay intended for infected patients, and disinfection of ambulances and medical equipment will be helpful in preventing the spread of COVID-19 in order to prevent and reduce the risk of infection.

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Consent for publication

Not required.

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request**.**

Conflict interest

The authors declare no conflicts of interest.

Author's contribution

XXX: Conceptualization, methodology, data collection, analysis and interpretation of data, and writing of the article; XXX: Supervision, critical review, revision and final approval of the version to be submitted; XXX: Supervision, critical review and revision; XXX: Supervision, analysis and interpretation of data; XXX: Review and editing.

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