MARCH 2024 | VOL. 9 | NO. 1

ISSN 2451–4691
E-ISSN 2543–5957

DISASTER AND EMERGENCY MEDICINE JOURNAL

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ORIGINAL ARTICLE

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DOI: 10.5603/demj.96069

ISSN 2451–4691, e-ISSN 2543–5957

HOW LONG TO PROVIDE SPECIAL CARE AFTER EMERGENCY DEPARTMENT ADMISSION IN THREE MOST COMMON NON-TRAUMATIC DISEASES?

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ABSTRACT

INTRODUCTION: The first hours after the admission of patients, and proper medical care is administered in the emergency department (ED), are of decisive importance in protecting them from unexpected death. Medical staff and researchers are not consistent in the period to follow up on deaths after admission to the emergency department and they analyze arbitrarily different time intervals without any justification for the chosen period. In this study, we will conduct an epidemiological data analysis to determine the range of the most dangerous (elevated) risk (hazard) of death for patients within one month of observation from an ED admission using modern survival modeling and software.

MATERIAL AND METHODS: Epidemiological data analysis of the three most common non-traumatic diseases (neoplasms, circulatory, and endocrine) was carried out in this study. Using the 2016–2019 sample of 14,904 first-visit ED patients at the Multi-Specialistic Hospital in Gorzów Wielkopolski, Poland, we determined the range of the most dangerous (elevated) risk (hazard) of death within one month of observation, based on a Royston–Parmar (RP) regression with spline functions (assuming non-constant hazard over time).

RESULTS: The results show that in the three most common non-traumatic diseases (neoplasms, circulatory, and endocrine) for the first 72 hours, patients should be under special supervision of medical personnel to avoid an excess of unexpected deaths. Moreover, within a month from ED admission, the hazard ratio (HR) of death was almost half as high [HR = 1.47, 95% confidence interval (CI) = 1.07 to 2.02] in diagnosed circulatory patients and over twice as high (HR = 2.25, 95% CI = 1.58 to 3.20) in neoplastic diseases as compared to reference endocrine patients. Moreover, the estimated RP hazards (probabilities of death) increased until the third day after admission, reaching 1.0% (95% CI = 0.8% to 1.4%) of endocrine patients, 1.5% (95% CI = 1.3% to 1.6%) of circulatory patients, and 2.2% (95% CI = 1.8% to 2.6%) for neoplasms, and then dropped radically with the time of observation.

CONCLUSIONS: In view of the care of patients in the three most non-traumatic clinical diagnoses (endocrine diseases, circulatory diseases, and neoplasms), special attention should be paid to the first three days after admission to the ED (after this time, in the first month of observation, the risk of death of these patients decreases significantly).

KEYWORDS: emergency department; non-traumatic diseases; death; Royston–Parmar model

Disaster Emerg Med J 2024; 9(1): 1–7

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Submitted: 16.06.2023 Accepted: 24.08.2023 Published online: 8.09.2023

INTRODUCTION

It can certainly be said that the first hours after admission of patients, and proper medical care administered in the emergency department (ED), are of decisive importance in protecting them from unexpected death (see, e.g. [1]). And so French researchers were wondering if unexpected deaths within 72 hours of an emergency department visit were preventable and they concluded, based on their sample, that the rate of unanticipated death within three days of an ED visit is 85 per 100,000 admissions and more than half of the unexpected deaths were related to a medical error that could have been prevented [1]. However, it is puzzling why the authors chose these 72 hours of observation and not another. Unfortunately, they do not explain this and it gives the impression that it was arbitrarily determined.

As cited in their paper, specific causes of mortality were not taken into account, and they considered all causes [1], in contrast, in the very current study by Reaven et al. [2], only deaths of patients from septic shock were evaluated at regular intervals 24 (5.5%), 48 (9.5%), and 72 hours (11.5%), after admission to the emergency department.

In turn, a seven-day observation period considered qualitative factors in patients who died shortly after an emergency department discharge was described by Gabayan et al. [3, 4]. In the latter study, the authors emphasize the importance of such analysis because early death after an ED discharge may signal opportunities to improve care and to identify patient and process of care-level themes that may provide possible explanations for early post-discharge mortality [4]. Based on a large research sample (nearly 300,000 patients and nearly 450,000 discharges), the authors observed that 0.05% of deaths occurred within 7 days of an ED discharge.

Stretching the observation period, deaths within 8 days after discharge were studied by Gunnarsdottir & Rafnsson [5]. In this sample, a non-causative diagnosis had been given to 11% of those who died within 8 days after discharge, while the mortality rate per 100,000 within 8 days was 208.5, within 15 days 347.4, and 30 days 648.6.

Based on a retrospective chart review, an eight-day follow-up of deaths of 2,665 medical examiner cases of patients after discharge from an ED was also conducted by Kefer et al. [6]. In the sample, the authors estimated the death rate in Milwaukee County of discharged patients was 13 per 100,000 and found death after discharge from an ED was uncommon.

Since death rates are an outcome that can be used to describe a service, Baker & Clancy [7] measured mortality rates within 30 days of discharge from an emergency department, or within 30 days of admission to an emergency department. The rates were 0.19% for those discharged, 4.6% for those admitted, and 0.27% for those patients who died while in an ED [7]. However, this study did not use sophisticated statistical tools and relied only on simple fractional calculations. Anyway, the authors believe that their numbers are sufficient to describe the outcome of an ED's services.

As can be seen from this brief review of the literature, medical staff and researchers do not agree on the length of the period to follow-up on deaths after admission to an emergency department and they arbitrarily analyze different time intervals without any justification for the chosen period. Also, the justification for the observation period can be trivial and unsupported by any reasonable scientific premise (e.g. [4] explain that "we chose the 7-day time frame because of its clinical relevance, implications for health policy decisions, and prior use in related studies", or [5]: "deaths within 8 days after discharge have, in previous studies, been evaluated retrospectively based on review of hospital records and the cause of death"). There is still no answer to the question: What is the period of treatment and observation of patients that are the most important for their survival from the moment they report to an emergency department?

Since the core mission of emergency medicine is to provide immediate care to acutely ill and injured patients [8], to extend the scope of ED observations, in this study we will conduct an epidemiological data analysis to determine the range of the most dangerous (elevated) risk (hazard) of death for non-traumatic patients within one-month of observation from an ED admission using modern survival modelling and software.

MATERIAL AND METHODS

We conducted a 2016–2019 single-center retrospective study from non-traumatic medical records and electronic data in the emergency department at the 1,000-bed public Multi-Specialistic Hospital in Gorzów Wielkopolski, Poland. Monthly, the hospital

has 1,200 admissions to the ED as ascertained from the codes of the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD10) [9].

We aimed to investigate the top three (most frequent) ICD10 non-traumatic diagnoses and 1- and 31-day mortality rates of patients after an ED contact (we chose this approach in order not to underestimate short-term mortality). In our study, the mortality day was defined as death on the same day as death registration, since death registration is available only by date and not by time of day.

Only the history of unduplicated patients after the first ED visit during follow-up was included in the statistical analysis. Using a sample of 14,904 patients (both living and deceased), we calculated the percentage of death in patients who died within one month from the first visit to an ED (subjects were restricted to age 18 years and older because of the inherent differences between pediatric and adult presentations and outcomes as well as due to taking into account the low probability of developing chronic diseases in younger patients; the cause of death was obtained from a nation-wide registry by record linkage from electronic administrative databases). Consequently, the highest percentage of deaths were within chapters 'Neoplasms' (12.3%), 'Circulatory' (8.5%), and 'Endocrine' diseases (3.9%). A graphical presentation of death ratios (= disease deaths/all deaths) during the month of observation is shown in Figure 1.

The lines attached in Figure 1 roughly show that the highest percentage of deaths in the three selected diagnoses (neoplasms, circulatory, and endocrine diseases) is observed in the first week after admission to an ED, and after two weeks this rate is close to zero.

This study was carried out in accordance with the Declaration of Helsinki and was approved by the Bioethical Committee (BC) of the District Medical Council in Zielona Góra, Poland (ref. 25/107/2018). Since the current study was retrospective and the subjects were de-identified, the BC waived the need for written consent.

Methods

Modeling of the censored survival data is preferably conducted by a Cox proportional-hazards regression. Because the Cox model is not without limitations, for example in the case of complex data, non-proportional hazards are a potential difficulty (when monotonicity of the survival function is affected in the region where the observed data are sparse; in regions where data are dense, monotonicity is effectively imposed by the data themselves). Then parametric approaches can be advantageous (even the originator of the Cox model has expressed a preference for parametric modeling, see [10]), and a Royston–Parmar (RM) approach [11] may be a reasonable alternative, which fits a restricted cubic spline to flexibly model the baseline log cumulative hazard on the proportional hazards scale. This feature incorporates time-dependent effects and permits measures of the hazard rates to be estimated at all time points (an important feature when using the model; despite the apparent advantages of the RP model, it is not widely used in health research [12]).

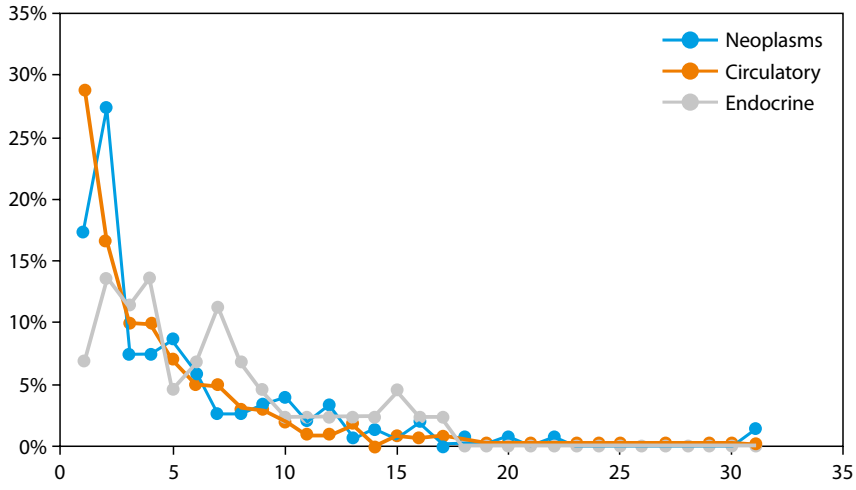

FIGURE 1. Death ratios in the selected ICD10 chapters since an emergency department (ED) admission

Table 1. The estimated hazard ratios between the selected ICD10 chapters, *i.e.* endocrine diseases, circulatory diseases, and neoplasms, and an ED within one month of observation

ICD10 chapter	HR	95% CI	p value
Endocrine diseases	1.00 (ref.)	–	–
Circulatory diseases	1.47	(1.07, 2.02)	0.0162
Neoplasms	2.25	(1.58, 3.20)	< 0.0001

CI — confidence interval; HR — hazard ratio

The novelty of this attractive approach relies on the fact that the survival function S(t) transformed by a link function g(.) is smoothed on the log time (t) scale against anticipated artifacts in the fitted spline functions that would be more severe for the hazard function. As a result, a class of such models can be created

$$g[S(t;z)] = g[S_0(t)] + \beta^T z,$$

where $S_0(t) = S(t;0)$ is the baseline survival function and β is a vector of parameters to be estimated for covariates z. In the spline-based survival RP model, a transformation $g(S_0(t,z))$ leads to some non-linear functions $s(x, \gamma)$, where $x = \log(t)$, having an adjustable parameter vector γ. The complexity of the model, thus the dimension of γ, is governed by the number of knots in the spline function s(.) [11].

Package 'flexsurv' [13] for R statistical platform [14] allows parametric distributions to be fitted to survival data, gaining the convenience of parametric modeling. Built-in choices include spline-based models with any number of knots and parameter-generalized gamma and F distribution families [11].

RESULTS

The presented results could not have been obtained otherwise than by using the Royston–Parmar spline regression model. In this study, the interpretation of statistical results is based on the classical hazard ratio (HR), which is the probability of an event in comparison groups relative to the reference group probability over a unit of time (this ratio is an effect size measure for time-to-event data).

Using the 'flexsurv' package, the estimated HRs of early death between the selected ICD10 chapters, *i.e.* endocrine diseases, circulatory diseases, and neoplasms, and in an ED within one month of observation are reported in Table 1. Based on the collected HRs it can be stated that the risk of an early death for patients at the analyzed ED is the lowest for patients with endocrine diseases, about half of it is higher for circulatory diseases, while the top rates are recorded for neoplasms.

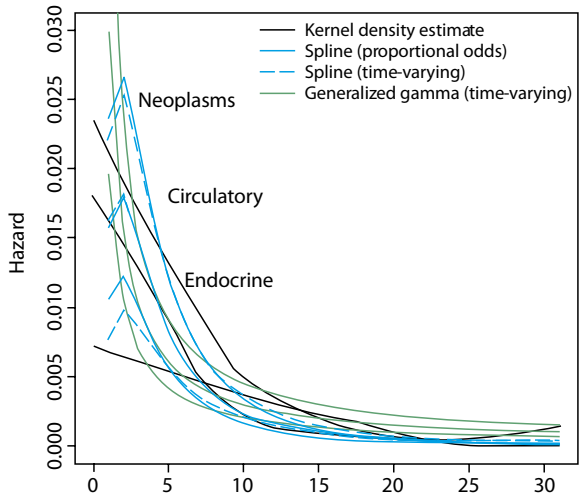

FIGURE 2. Hazard curves of death of patients vs days after admission to the emergency department

The plot of the estimated Royston–Parmar hazard (probability of death) after admission to the ED, created in the 'flexsurv' package, is presented in Figure 2.

The modeled RP hazard curves in Figure 2 increased until the third day after admission, reaching 1.0% (95% CI = 0.8%, 1.4%) hazard of endocrine patients, 1.5% (95% CI = 1.3%, 1.6%) of circulatory patients, and 2.2% (95% CI = 1.8%, 2.6%) for neoplasms, and then dropped radically with the time of observation. It can also be seen that the course of the hazard curves in Figure 2 is similar to the death ratios in Figure 1.

DISCUSSION

Proper medical care administered in the emergency department is of decisive importance in protecting patients from unexpected death. Following the literature, however, the time of observation of the risk

of unexpected events is undetermined, inconsistent, and chosen arbitrarily.

Since emergency departments handle a large proportion of traumatic patients with orthopedic fractures and other bodily injuries as a result of road accidents and workplace accidents, or violence to a person, etc., (these cases are often classified as acute, and patient survival a priori has no causal relationship with their previous lifestyle and chronic disease status), it seemed equally attractive to us to deal with non-traumatic cases. Hence, in our study, the same data that was originally used in a study [9] to predict acute mortality in emergency department patients based on selected hematological biomarkers (the huge and only partially exploited set of these data was an incentive to continue research on the survival of patients admitted to ED), we decided to analyze in a brand-new observational study. Although, the downside of the research material collected is the lack of precise data on the cause of death of the patients. However, due to the short observation time, we trust that it did not deviate significantly from the patients' diagnosis specified by the ED (also, the lack of ED discharge times is a limitation of this study, however, it is difficult to say whether it had any impact on fatal clinical events, as well as medical misdiagnoses, which were also not investigated in this study).

Still, in our study, we found that with the help of commonly available methods and software, it is possible to precisely determine the time of special care for patients from the time of their admission to the ward. Moreover, the premise for such modeling as with the RP method may be the calculation of simple ratios of adverse events to all cases (in our study, fatalities). It seems that our statistical proposal is correct because a query of scientific publications made us realize the following.

After researching articles on patient deaths after admission to the emergency department, it is safe to say that most of them are based on survival analysis using the Kaplan–Meier method. This was the case with, for example, an analysis of the two-month survival of patients with congestive heart failure without hospital readmission reported by Chin & Goldman [15], for patients with and without visits to the emergency department for self-harm, suicide attempts, or an overdose [16], about the long-term mortality in older hospitalized patients with and without delirium within six months after an ED visit [17], and in three hundred French medical patients aged 80 during several years of observation [18], or in the much shorter five-day timeframe in adults with septic shock relative to time from an emergency department triage [2]. A methodologically different statistical perspective on the mortality of patients in a pediatric emergency department at a tertiary medical center in China had Zhu et al. [19], presenting deaths in three subgroups of children: on arrival, within 24 hours, and over 24 hours after ED admission by several types of diseases/disorders. However, it seems that all the analyzed time intervals were created arbitrarily and have no practical significance, e.g. in reducing premature deaths of patients and focusing on the most important period of clinical observation and treatment after an ED admission. For this purpose, an unsurpassed statistical solution seems to be RP regression with spline functions, whose importance, still underestimated by the medical world, may play a huge role in recognizing and assessing "sensitive" risk periods of observation of patients.

In our study, this statistical time result can be obtained in, for example, the 'flexsurv' R package which is easy to use for practitioners. We trust that this idea can be successfully used in the analysis of other clinical responses over time. There remains the question of explaining the causes of such a confirmed epidemiological situation, but this is a problem for another scientific clinical study.

CONCLUSIONS

Based on the collected statistical material and the results obtained, the following conclusions can be drawn:

1. A review of the literature indicates the assumption of an arbitrary observation period of patients admitted to an ED and the lack of standardization in order to protect patients from unexpected health effects.
2. A Royston–Parmar regression with the use of 'flexsurv' R package spline functions allows for an original, reliable, and precise assessment of the risk ranges of the occurrence of the analyzed clinical response and can be used in a wide research spectrum.
3. For selected ICD10 chapters, *i.e.* endocrine, circulatory, and neoplasms, this technique used the indicates an increase in patient mortality up to the third day after admission to an ED. Until then, patients should be under special supervision of medical personnel in order to avoid an

excess of unexpected deaths After this period the risk of death decreases radically.
4. Attempts at longer observation periods do not statistically significantly improve the statistics of sudden deaths after admission to the hospital ED.

Article information and declarations

Data availability statement

All datasets an R codes used in the analysis are shared as part of this publication.

Ethics statement

This study was carried out in accordance with the Declaration of Helsinki and was approved by the Bioethical Committee (BC) of the District Medical Council in Zielona Góra, Poland (ref. 25/107/2018). Since the current study was retrospective and the subjects were de-identified, the BC waived the need for written consent.

Author contributions

Wawrzyniec Mantorski, Piotr Feusette, Andrzej Tukiendorf, and Edyta Wolny-Rokicka were involved in study concept, interpretation of the data, and in critical revision of the manuscript for important intellectual content. Edyta Wolny-Rokicka (previously employed at the Multi-specialist Hospital in Gorzów Wielkopolski, Poland) was involved in acquisition of the data. Andrzej Tukiendorf provided statistical expertise.

Funding

The authors received no financial support for the research and authorship of this article.

Acknowledgments

We are grateful to Dr. Christopher Jackson from MRC, Cambridge, UK, for his scientific supervision during the statistical analysis. We also thank the anonymous reviewer for his careful reading of our manuscript and many insightful comments on an earlier draft.

Conflict of interest

The results of the study and their possible publication do not result in any conflict of interest.

Supplementary material

None.

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ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 8–15
DOI: DEMJ.a2023.0017

ISSN 2451–4691, e-ISSN 2543–5957

RISK FACTORS RELATED TO COVID-19 SURVIVAL AND MORTALITY: A CROSS-SECTIONAL-DESCRIPTIVE STUDY IN REGIONAL COVID-19 REGISTRY IN FASA, IRAN

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ABSTRACT

INTRODUCTION: The COVID-19 pandemic, as the most important health challenge in the world today, has made numerous irretrievable damages to the social, economic, and health dimensions of societies, especially in developing countries. An essential measure that can be taken to prevent and control the disease is to identify risk factors related to its prognosis and mortality rate. Therefore, this study aimed at investigating COVID-19 survival and mortality risk factors and their relationship with the demographic characteristics of the subjects diagnosed with the disease.

MATERIAL AND METHODS: The present study is cross-sectional and descriptive. The samples consist of 1395 patients diagnosed with COVID-19 admitted to medical centers affiliated with Fasa University of Medical Sciences. The subjects were selected by census sampling. Data were collected using demographic information forms, paraclinical and radiological tests, and clinical examinations. Data were analyzed using SPSS version 18 via descriptive tests, paired t-tests, one-way ANOVA, and post hoc tests.

RESULTS: According to the data, the participants' average age was 57.72 ± 4.63 years, and most of them (56.41%) were male. The mortality rate among the participants was estimated to be 13.19%. The results of the study showed a significant relationship between the survival status of patients with COVID-19 and underlying chronic diseases such as diabetes and cardiovascular and renal diseases ($p < 0.05$).

CONCLUSIONS: Identifying high-risk groups is an important measure that health professionals should consider in controlling epidemics. The findings of this study showed that the presence of underlying chronic diseases such as diabetes and cardiac and renal conditions, which are associated with immune system defects, are among the most important factors related to the COVID-19 mortality.

KEYWORDS: COVID-19; risk factors; survival status; underlying diseases

Disaster Emerg Med J 2024; 9(1): 8–15

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Received: 23.12.2022 Accepted: 18.03.2023 Early publication date: 21.04.2023

INTRODUCTION

In December 2019, several cases of acute respiratory disease were reported, the first being in Wuhan City, Hubei Province, China [1, 2]. The disease, which was originally known as coronavirus pneumonia and was later called COVID-19, quickly spread from Wuhan to other parts of the world, to the extent that the World Health Organization declared the COVID-19 outbreak a global pandemic [3].

The virus, called SARS-CoV-2, is transmitted by respiratory droplets that symptomatic patients release when coughing and sneezing, but may also be transmitted by asymptomatic carriers before symptoms begin. Although the virus has been observed in clinical specimens like the tears and feces of positive patients with COVID-19, the transmission of the disease through the mouth, feces, or conjunctiva is still contested. Studies have shown higher viral loads in the nasal cavity than in the throat, with no difference in viral loads between symptomatic and asymptomatic individuals [4, 5]. The incubation period of the SARS-CoV-2 can reach up to 14 days with a median of 2.5 days. Almost all patients experience one or more symptoms within 5–12 days of contracting the virus [6].

The COVID-19 clinical symptoms are heterogeneous and range from mild symptoms such as fever, dry cough, and shortness of breath to acute respiratory distress syndrome (ARDS) which may ultimately lead to death. Moreover, an asymptomatic period has also been reported, which poses a challenge to controlling the infection [7, 8].

Given the complexity of its transmission and lack of established treatments, COVID-19 is highly challenging at the global level [9, 10]. This is particularly catastrophic for middle- and low-income countries with low levels of health literacy, weak health care system, and insufficient critical care facilities [11].

Although many countries have started vaccination, considering the complicated nature of the virus, new variants have been emerging in different parts of the world [12] indicating the importance of addressing all dimensions of the COVID-19 pandemic and the related health challenges.

Based on global reports, clinical characteristics and health status of COVID-19 patients are important factors affecting their recovery and mortality rate [13]. Despite unsparing efforts by researchers and experts to better understand the diagnostic and clinical features of the disease, our current understanding of mortality risk factors in patients with COVID-19 is still limited [14, 15]. Such risk factors are not widely identified, and many have remained in a state of uncertainty. Therefore, considering the importance of identifying risk factors and their role in adopting prevention, treatment, and rehabilitation programs and strategies, this study also aimed at determining COVID-19 mortality risk factors and the patient's demographic characteristics.

MATERIAL AND METHODS

The current study is cross-sectional, descriptive, and analytical. The research population included all the COVID-19 patients in the city of Fasa in 2020–2021.

Sample size and sampling method

The sampling was carried out based on census. All patients with COVID-19 admitted to the medical centers of Fasa University of Medical Sciences who were registered in the COVID-19 System were invited to participate in the study. A total of 1395 people entered the study.

Procedure

After the proposal was approved by the Research Deputy of the university and received the code of ethics permission from the university's Research Committee, the researcher referred to the university's Treatment Deputy to carry out the study. The participants' demographic and clinical data extracted from the COVID-19 system were analyzed. Moreover, in order to obtain precise clinical information, the researcher referred to the medical centers affiliated with the university and examined the participants from admission to discharge or death.

Data collection instruments

A demographic information questionnaire, paraclinical data, and clinical examinations were used to collect data in this study.

Demographic information questionnaire

The questionnaire included personal information (age, sex, marital status, place of residence, education, occupation, illness duration, and history of physical illness).

Paraclinical data

Paraclinical data included the results of all tests performed by the relevant specialists for the participants

Table 1. The relationship between survival status and demographic characteristics of the participants

Variable n (%)		Survival status				p value
		Death		Survival		
		Percentage	Number	Percentage	Number	
Age		15.1	71.98	18.73	55.55	< 0.001
Gender	Female	42.9	79	43.7	529	0.45
	Male	57.1	105	56.3	682	
Marital status	Single	0	0	1.3	16	0.10
	Married	100	184	98.7	1195	
Education	Illiterate	45.7	84	26.2	317	< 0.001
	Below High School Diploma	21.7	40	19	230	
	High school Diploma	26.6	49	38.2	463	
	High School Diploma and above	6	11	16.6	201	
Smoking	No	40.8	75	36.7	445	0.16
	Yes	59.2	109	63.3	766	
Alcohol consumption	No	40.2	74	36.3	440	0.17
	Yes	59.8	110	63.7	771	

during the treatment period. The participants' radiology test results were also analyzed. All laboratory results were collected using hospital electronic records. Reverse transcriptase polymerase chain reaction (RT-PCR) was performed on nasopharyngeal samples, which precisely describe the characteristics of the diagnostic kit. In summary, total RNA was extracted using High Pure RNA Isolation (Roche Diagnostics, Penzberg, Germany). RT-PCR for coronavirus genes was performed with Taqman® Premix TAKARA (TaKaRa, Dalian, China) according to the manufacturer's recommended protocol.

Clinical examinations

The results of vital sign assessment and the state of body systems monitored by medical professionals during hospitalization or visits to medical centers were analyzed.

Data analysis

SPSS version 18 was used for data analysis. Descriptive statistics indicators including frequency, percentage, mean, and standard deviation as well as inferential statistics such as; independent t-test, Chi-square, and ANOVA, were used to analyze the data. Logistic regression was used to determine the risk factors associated with COVID-19 contracting and mortality and the confounding factors. A p value less than 0.05 ($p \leq 0.05$) was considered as statistically significant.

Ethical approval

Informed written consent was obtained from all the participants before participating in the study. The present study was conducted in accordance with the principles of the revised Declaration of Helsinki, a statement of ethical principles, which directs physicians and other participants in medical research involving human subjects. The participants were assured about the anonymity and confidentiality of their information Moreover, the study was approved by the local Ethics Committee of Fasa University of Medical Sciences, Fasa, Fars province, Iran (Ethics code: IR.FUMS.REC.1400.151)

RESULTS

The participants in the current study included a total number of 1395 patients with COVID-19 who were registered in the COVID System. According to the data, the participants' average age was 57.72 ± 4.63 years, and most of them (56.41%) were male. The mortality rate among the participants was estimated to be 13.19%. Data analysis did not show any significant difference between gender, marital status, smoking, and alcohol consumption in regard to their relationship with the participants' survival status (Tab. 1).

Results also indicated a significant difference ($p < 0.05$) between the survival status of people

Table 2. The relationship between survival status and underlying diseases of the participants

Variable n (%)		Survival status				p value
		Death		Survival		
		Percentage	Number	Percentage	Number	
Diabetes	Yes	29.3	54	8.5	103	< 0.001
	No	70.7	130	91.5	1108	
Cardiovascular diseases	Yes	54.3	100	11.3	137	< 0.001
	No	45.7	84	88.7	1047	
Chronic renal disease	Yes	37	68	3.1	37	< 0.001
	No	63	116	96.9	1174	
Chronic hepatic disease	Yes	2.2	4	0.3	4	0.01
	No	97.8	180	99.7	1207	
Autoimmune diseases	Yes	2.2	4	0.2	3	0.007
	No	97.8	180	99.8	1208	
Cancer	Yes	0	0	0.2	3	0.65
	No	100	184	99.8	1208	
Chronic pulmonary disease	Yes	1.1	2	0.7	9	0.43
	No	98.9	182	99.3	1202	
ICU admission	Yes	67.4	124	19.7	238	< 0.001
	No	32.6	60	80.3	973	

ICU — intensive care unit

with COVID-19 and underlying diseases such as diabetes, cardiovascular diseases, chronic renal diseases, and autoimmunity as well as hospitalization in the ICU department ($p < 0.05$). There was no significant difference between cancer, organ transplant, and chronic pulmonary diseases in terms of their relationship with the survival status of COVID-19 patients (Tab. 2).

There was a significant relationship between the survival status of patients and symptoms of fever, chills, muscle pain, sore throat, shortness of breath, nausea, diarrhea, and cough (new or exacerbation of chronic cough) ($p < 0.05$). However, the relationship was not significant for runny nose, abdominal pain, and anosmia (Tab. 3).

According to results, survival status was significantly related to levels of hemoglobin O_2 saturation, hemoglobin, platelet count, urea nitrogen, creatinine, white blood cells, lymphocytes, and neutrophils in the blood ($p < 0.0001$), but its relationship with sodium and potassium levels was not significant. The relationship between mortality and hemoglobin O_2 saturation, cardiovascular diseases, chronic renal disease, hypoxemia symptoms, and hospitalization in the ICU was significant in the presence of other variables ($p < 0.05$) (Tab. 4).

DISCUSSION

The purpose of the present study was to investigate risk factors of COVID-19 infection and related mortality and demographic characteristics in 1395 patients at Fasa University of Medical Sciences. Initial results indicated that the mortality of COVID-19 patients was significantly related to diabetes, cardiovascular diseases, chronic renal diseases, and chronic hepatic diseases. Most patients who died after contracting SARS-CoV-2 had reported diabetes, cardiovascular diseases, and chronic renal disease. In the same vein, the results of a retrospective study conducted by Wostyn et al. [13] found that the most frequent common comorbidities observed in COVID-19 patients were diabetes mellitus (48.26%) and hypertension (45.27%). Therefore, it can be concluded that inflammatory conditions, diagnosis with concomitant diseases, especially uncontrolled diabetes mellitus, and the use of steroids were associated with long-term hospitalization.

Diabetic patients are at a higher overall risk of infection because they are more likely to suffer from multiple innate immune defects. Since overall mortality from cardiovascular diseases is decreasing among diabetic patients, pneumonia with various pathogens has become an important mortality risk

Table 3. The relationship between survival status and clinical symptoms of the participants

Variable n (%)		Survival status				p value
		Death		Survival		
		Percentage	Number	Percentage	Number	
Fever	Yes	78.3	144	54.3	658	< 0.001
	No	21.7	40	45.7	553	
Shivering	Yes	91.8	169	78.3	948	< 0.001
	No	8.2	15	21.7	263	
Muscular pain	Yes	77.2	142	43.1	522	< 0.001
	No	22.8	42	56.9	689	
Runny nose	Yes	7.1	13	8	97	0.39
	No	92.9	171	92	1114	
Sore throat	Yes	75.5	139	68.4	828	0.02
	No	24.5	45	31.6	383	
Shortness of breath	Yes	92.9	171	71.8	870	< 0.001
	No	7.1	13	28.2	341	
Nausea	Yes	19	35	6.8	82	< 0.001
	No	81	149	93.2	1129	
Stomachache	Yes	84.2	155	78.2	947	0.03
	No	15.8	29	21.8	264	
Diarrhea	Yes	12.5	23	2.8	34	< 0.001
	No	87.5	161	97.2	1177	
Cough (new or exacerbation of chronic cough)	Yes	20.1	37	4.5	55	< 0.001
	No	79.9	147	95.5	1156	
Dry cough	Yes	21.2	39	57	690	< 0.001
	No	78.8	145	43	521	
Productive cough	Yes	58.7	108	14.7	178	< 0.001
	No	41.3	76	85.3	1033	
Anosmia	Yes	48.4	89	1.6	19	< 0.001
	No	51.6	95	98.4	1192	

factor in these patients. There is currently no consensus on whether people with diabetes are more vulnerable to COVID-19, but it is assumed that they are at a greater risk of infection, severe illness, and death. For example, the first three COVID-19 deaths in Hong Kong all occurred in diabetic patients [16]. On the other hand, COVID-19 patients, especially those with severe respiratory complications, are faced with an increased risk of mortality. In addition, COVID-19 not only can progress to a severe acute respiratory syndrome, but also can disrupt the proper functioning of other organs (such as the heart, kidneys, and liver), indicating the need for special care in these patients [17]. Therefore, it can be concluded that the results of the present study are consistent with the results of the mentioned studies.

The results of a review study conducted by Gao et al. [18] showed cases of acute kidney damage in COVID-19 patients. Evidence has shown that the virus can directly cause kidney damage. This damage can be attributed to changes in the amount of oxygen in the body, which can be harmful to the kidneys. These results are in line with the results of the present study.

Other results of the study showed a significant relationship between the COVID-19 patients' survival status and symptoms of fever, chills, muscle pain, sore throat, shortness of breath, nausea, diarrhea, and dry or productive cough (new or exacerbation

Table 4. The relationship between survival status and paraclinical data of the participants

Variable	Survival status						p value
	Death			Survival			
	Standard Deviation	Mean	Number	Standard Deviation	Mean	Number	
O_2 Sat	7.38	78.04	160	4.06	90.13	1073	< 0.001
HB	2.3	12.23	184	1.89	12.72	1211	0.007
PLT	84.42	182.74	177	91.30	208.76	1194	< 0.001
BUN	33.27	37.14	182	12.82	17.51	1171	< 0.001
Cr	1.36	1.73	178	2.39	1.21	1154	< 0.001
Na	21.90	129.90	179	15.99	131.86	1111	0.25
WBC	5.18	9.45	174	4.49	7.10	1177	< 0.001
Lym	7.47	12.15	166	15.14	21.88	1164	< 0.001
Neut	9.08	82.54	159	30.90	72. 29	1093	< 0.001

O2 Sat — Oxygen saturation; HB — Hemoglobin; PLT — Platelets; BUN — Blood urea nitrogen; Cr — Creatinine; Na — Sodium; WBC — White blood cells; Lym — lymphocytes; Neut — Neutrophils

of chronic cough). Thus, patients who reported more respiratory symptoms were in a more unfavorable condition. The mentioned results are consistent with that of Wang et al. [17] who reported high mortality for COVID-19 patients, especially those with severe respiratory complications and low levels of oxygen saturation. Long-term hyperpyrexia indicates intracellular inflammatory reactions, which is considered an unfavorable prognosis in affected patients. On the other hand, hepatic involvement in COVID-19 can be related to the direct cytopathic effect of the virus, uncontrolled immune responses, sepsis, or drug-induced liver injury. The proposed mechanism of SARS-CoV-2 entry into cells is through angiotensin-converting enzyme 2 (ACE2) receptors, which are abundant in alveolar type II cells. ACE2 receptors are mostly expressed in the digestive system, vascular endothelium, and Cholangiocytes of the liver, causing fever, muscle pain, and digestive problems [19].

The results of the study showed no significant relationship between survival status and gender, marriage, smoking, and alcohol consumption. Likewise, Chadeau et al. [20] found that male sex, lower education level, and non-white ethnicity were associated with the risk of contracting COVID-19. In this regard, the results of a case-cohort study by Mirjalili et al. [21] conducted in Iran showed that mortality was higher in the case group and elderly people compared to other patients. They recommended that special attention be given to at-risk and elderly patients in terms of providing proper diet, strengthening self-care, and providing long-term medical and healthcare facilities. Older patients with lymphopenia, hypomagnesemia, high CRP, and/or high creatinine upon admission are at a higher risk of mortality from COVID-19 infection, showing the need for timely and strong treatment measures for this age group by healthcare professionals [22]. Another study found an association between the male gender and lower education level with the risk of contracting COVID-19 [20]. These results are inconsistent with the results of the present study. This discrepancy can be attributed to the fact that the current study is a cross-sectional study and can only show a correlation among variables, while the mentioned studies are cohort-based and longitudinally designed with a higher ability to determine cause and effect relationships. In this regard, an all-embracing systematic review study is recommended to pinpoint points of consensus in the results of such studies.

Study limitation

The literature on coronavirus continues to accumulate, with new information and new papers published each day; therefore, our study cannot be considered exhaustive and might not recognize the possible other factors that affect COVID-19 mortality.

Strength of study

Although many studies have been conducted in the field of COVID-19 in other countries, the study based on the COVID -19 registry with large sample size is limited. One of the strengths of the present study is the large sample size and the use of data from the COVID-19 registry.

CONCLUSIONS

According to the results of the present study, a history of underlying chronic diseases including diabetes and cardiovascular, renal, and hepatic diseases was the most important risk factor related to the survival status of COVID-19 patients. Given the nature of these diseases and their negative effects on the immune system, they expose COVID-19 patients to more severe complications leading to a higher mortality rate. Therefore, it is essential that healthcare professionals and managers consider preventive measures and programs with a higher level of efficiency for these patients. This is particularly important given that lack of a multidimensional approach to the problem in question can put the lives of the affected people at risk. Moreover, it can incur huge economic costs for the healthcare system society. Therefore, it seems that identifying target groups and providing necessary training to them to prevent infectious diseases such as Covid-19 will be the most important and first necessary action. This requires an all-round and collaborative action by all people in the healthcare team, including nurses, physicians, and healthcare professionals.

Article information and declarations

Acknowledgment

The authors appreciate Fasa University of Medical Sciences for financially supporting this research. Also, authors would like to appreciate Fasa University of Medical Sciences & Clinical Research Development Unit of Fasa Valiasr hospital for financially supporting this research.

Funding

This project was carried out under the financial support of the Research Deputy of Fasa University of Medical Sciences (project number: 400134).

Conflict of interests

There are no conflicts of interest.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 16–22
DOI: 10.5603/DEMJ.a2023.0029

ISSN 2451–4691, e-ISSN 2543–5957

SYSTEMATIC REVIEW AND META-ANALYSIS OF THE CO-OCCURRENCE OF ATRIAL FIBRILLATION AND LIVER TRANSPLANTATION: A LETHAL COMBINATION

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ABSTRACT

INTRODUCTION: This systematic review and meta-analysis is aimed to evaluate the role of new-onset atrial fibrillation (NOAF) in patients after liver transplantation (LT) and determine the effect of NOAF on the incidence of mortality and graft rejection.

MATERIAL AND METHODS: Published studies until the end of April 15, 2023, were systematically searched in PubMed, Google Scholar, Scopus, Embase, Web of Science, and the Cochrane databases. Odds ratios (ORs) with 95% confidence intervals (CI) for mortality and graft rejection were extracted.

RESULTS: Five studies with a total of 4788 unique post-LT patients were included in the meta-analysis. Pooled analysis showed that mortality in patients with and without NOAF varied and amounted to 24.1% vs 12.5%, respectively (OR = 2.51; 95% CI: 1.92 to 3.27; $p < 0.001$). Moreover, pooled analysis showed that graft rejection in the NOAF cohort was 26.3%, and was higher vs patients without NOAF (13.1%; OR = 2.98; 95% CI: 2.14 to 4.15; $p < 0.001$)

CONCLUSIONS: Post-LT NOAF is associated with increased mortality and a higher risk of graft rejection. It is likely that the development of a standard procedure for early identification of NOAF, as well as to develop recommendations for specific treatment targeted at avoiding the impacts of the illness, could provide a mortality reduction and provide an increased rate of successful LT.

KEYWORDS: ATRIAL fibrillation; risk assessment; mortality; graft rejection; liver transplant

Disaster Emerg Med J 2024; 9(1): 16–22

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Submitted: 3.07.2023 Accepted: 14.07.2023 Published online: 1.08.2023

INTRODUCTION

For individuals with end-stage liver disease or acute liver failure, liver transplantation (LT) is a life-saving treatment. In 2021, the number of liver transplants done in the United States reached a new high of 9,234, representing a continuing trend of steady growth [1]. LT is still considered to be one of the most dangerous noncardiac surgical operations, and despite major advances in surgical procedures and postoperative treatment, problems in the immediate and long-term postoperative periods remain prevalent. In the early postoperative period following a liver transplant, infection, and rejection have been described as important causes of death [2, 3]. However, severe cardiovascular events remain a prevalent cause of long-term morbidity and mortality [4]. In patients who have a limited physiological reserve, hemodynamic instability, systemic inflammation, and electrolyte imbalances all provide a considerable risk of perioperative cardiovascular morbidity and death [5, 6]. New-onset atrial fibrillation (NOAF), is the most common cardiovascular complication occurring in LT patients. New-onset atrial fibrillation is defined as AF that develops for the first time after LT in patients without a prior history of AF. Given the presence of increased sympathetic flow, perioperative hemodynamic alterations, and the frequent need for vasopressors following surgery, patients with LT are theoretically at a greater risk of developing NOAF [7]. A recent pooled investigation reported that the frequency of atrial fibrillation following surgery was 8.5%. New-onset atrial fibrillation is particularly troublesome in the initial post-LT period as it may result in high central venous pressure with the consequence of inadequate graft venous outflow [8]. Therefore, this systematic review and meta-analysis is aimed at evaluating the role of NOAF in patients after LT and determining the effect of NOAF on the incidence of mortality and graft rejection.

MATERIAL AND METHODS

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [9]. The study protocol was developed a priori, and all authors agreed to follow the protocol, which was not modified throughout the study.

Literature search strategy

An online search was conducted independently by two reviewers (F.C. and M.P.) on April 15, 2023, in PubMed, Google Scholar, Scopus, Embase, Web of Science, and the Cochrane electronic databases to detect the studies to include in the meta-analysis. Discussion with a third reviewer settled any possible differences between reviewers (L.S.). We used the keyword string "new-onset atrial fibrillation" OR "new-onset atrial fibrillation" OR "NOAF" OR "postoperative atrial fibrillation" OR "atrial fibrillation" OR "AF" OR "arrhythmia" AND "liver transplant" OR "liver transplantation" OR "hepatic transplantation" OR "hepatic transplant". Additionally, reference lists and referencing publications from the included research were examined. To eliminate queue overlapping, only the most recent or intact reports by the same author were used. When two papers related to the same group of patients were available, the one with the most participants was utilized. EndNote (version X9, Clarivate Analytic) was used to handle all references and delete duplicates.

Study selection

We restricted our search to adult human studies: 1) comparing patients after LT with and without NOAF; 2) with accessible and essential data; and 3) published in English. Excluded studies met the following criteria: (1) did not present a comparison group; (2) reviews, conference abstracts, case reports, or case series.

Data extraction

The papers were evaluated by two reviewers (F.C. and N.L.B.) who extracted data from each article using a pre-defined, standardized data form. When the first conclusions were questionable, a third reviewer (L.S.) evaluated the literature. The following information was gathered from the studies: (1) initial author, publication date, and place of origin; (2) research design; (3) kind of participant group; (4) case numbers; (5) age and sex; and (6) outcomes.

Outcomes and definitions

Based on the available outcomes of the included studies, the following end-points were assessed:

1. impact of NOAF in patients undergoing LT on mortality;
2. impact of NOAF in patients undergoing LT on graft rejection.

New-onset atrial fibrillation was defined as the first diagnosis of AF within 30 days following LT in individuals with no electrocardiogram abnormalities at the time of transplantation and no previous histo-

ry of AF in the medical record. New-onset atrial fibrillation was defined as the first diagnosis of AF within 30 days following surgery in individuals who had no ECG abnormalities at the time of LT and no previous history of AF in the medical record. Graft failure was defined as patients who required re-transplantation or died as a result of initial graft rejection.

Assessment of study quality

Two reviewers (F.C. and M.P.) independently evaluated the risk of bias in the included studies. Any differences between reviewers were settled with the help of a third reviewer (N.L.B.). The Newcastle-Ottawa Scale (NOS) [10] was used to assess the likelihood of bias in individual cohort studies. NOS assesses the quality of research using three criteria: selection, comparability, and exposure. These three aspects received maximum ratings of 4, 2, and 3 stars, respectively. Studies with NOS ratings of 7 were deemed high-quality.

Statistical analysis

The RevMan (ver. 5.4; Cochrane Collaboration, Oxford, UK) was used for all statistical analyses. The Mantel-Haenszel technique was used to calculate the pooled prevalence. The results are displayed as forest plots with 95% confidence intervals (CIs) using odds ratios (ORs). For dichotomous data, the mean difference (MD) and 95% confidence interval are used. When data were presented as medians with an interquartile range, Hozo's algorithm was used to calculate estimated means and standard deviations [11]. The I^2 test was used to examine study heterogeneity, which was classified as low, moderate, or high when I^2 was $< 50\%$, 50–75%, or $> 75\%$, respectively [12]. If I^2 was $> 50\%$, the random-effects model was used; otherwise, the fixed-effects model was utilized. If there were more than 10 trials in a single meta-analysis, Egger's test and funnel plots were employed to analyze possible bias and run funnel plot tests for asymmetry to investigate potential publication bias. All p values were calculated using a two-sided test and were defined as < 0.05.

RESULTS

Classification

Figure 1 depicts the flowchart of the literature search. Our search identified 418 articles, of which 5 remained after screening, that included a total of 4788 unique post-LT patients [13–17]. The number

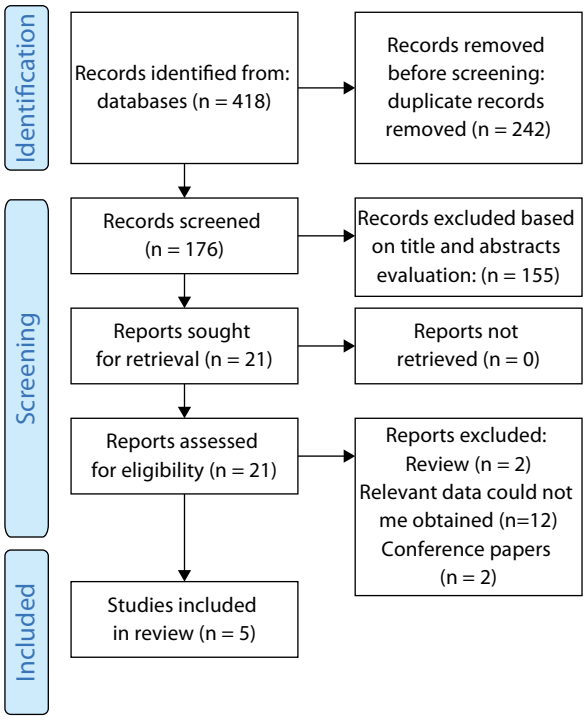

FIGURE 1. A flowchart depicting the study selection process

of patients per study ranged from 461 to 1387 (Tab. 1). All studies were performed as retrospective cohort studies. The articles analyzed in this meta-analysis were published between 2015 and 2022. Of the 5 trials, two were performed in the USA [15, 17], and one each in Australia [13], Spain [16], and the Republic of Korea [14]. The methodologic quality of the included trials was low, as summarized in Table 1.

Statistical analysis

All five included studies reported mortality among patients with and without NOAF after LT [13–17]. Pooled analysis showed that mortality in patients with and without NOAF varied and amounted to 24.1% vs 12.5%, respectively (OR = 2.51; 95% CI: 1.92 to 3.27; $p < 0.001$; Fig. 2).

A secondary outcome of this meta-analysis was the impact of NOAF on graft rejection. This parameter was reported in three studies [14, 15, 17]. Pooled analysis showed that graft rejection in the NOAF cohort was 26.3%, and was higher vs patients without NOAF (13.1%; OR = 2.98; 95% CI: 2.14 to 4.15; $p < 0.001$; Fig. 3).

DISCUSSION

In this meta-analysis, we demonstrated that NOAF after LT is a cause for concern, as our pooled analysis

Table 1. Baseline characteristics of the included trials

Study	Country	Study design	Study group	Age	Female (%)	BMI, [kg/m^2]	Hypertension	Diabetes	MELD score	NOS score
Koshy et al., 2021 [13]	Australia	Retrospective cohort study	PO-AF	63.6 ± 6	11 (23.4)	27.9 ± 5	36.20%	29.8%	21 ± 10	8
			No PO-AF	56.6 ± 12	138 (33.3)	26.7 ± 6	39%	31.5%	19 ± 9	
Moon et al., 2018 [14]	Republic of Korea	Retrospective cohort study	PO-AF	45.4 ± 8.7	8 (61.5)	NS	3 (23.1)	3 (23.1)	31.5 ± 11.2	9
			No PO-AF	50.6 ± 8.7	266 (25.4)	NS	112 (10.7)	202 (19.3)	18.8 ± 9.8	
Rachwan et al., 2020 [15]	USA	Retrospective cohort study	PO-AF	NS	27%	NS	38%	43%	NS	8
			No PO-AF	NS	34%	NS	36%	29%	NS	
Rivas et al., 2022 [16]	Spain	Retrospective cohort study	PO-AF	60 ± 8	35%	30 ± 7	45%	14%	23 ± 7	9
			No PO-AF	55 ± 10	35%	31 ± 8	57%	13%	27 ± 8	
Xia et al., 2015 [17]	USA	Retrospective cohort study	PO-AF	58.8 ± 9.1	32.4%	29.6 ± 6.3	38.0%	NS	35.5 ± 7.1	8
			No PO-AF	54.0 ± 11.4	36.3%	27.7 ± 6.0	32.7%	NS	31.7 ± 7.7	

BMI — body mass index; MELD — model for end-stage liver disease; NS — not specified; PO-AF — postoperative atrial fibrillation

discovered that it is linked with a considerably elevated mortality risk. Pooled analysis showed that mortality in post-LT patients with and without NOAF varied from 24.1% to 12.5%. Previous research has shown that individuals with NOAF are more likely to have a stroke, hemodynamic instability, a longer hospital stay, and greater healthcare costs [18]. In our study, NOAF was also linked to an increased likelihood of graft rejection, which was 26.3% in the NOAF group compared to 13.1% in those without NOAF. However, the mechanism behind this link remains unknown. The occurrence of post-LT NOAF is linked not only to acute kidney damage that occurs after the transplant but also to cerebrovascular events that occur [19]. Elevated filling pressures related to AF may result in both pulmonary and venous congestion that may contribute to inferior graft outcomes. Further, altered hemodynamics, as a result of inadequate NOAF heart rate management, may also contribute to possible pathophysiological reasons for graft failure associated with NOAF.

Our study shows that post-LT NOAF is not a benign disease and that it requires constant monitoring and management. According to the 2019 AHA as well as 2022 ERC guidelines, beta-blockers should be maintained postoperatively to minimize serious cardiovascular events [20, 21]. Furthermore, the American Association for Thoracic Surgery recommends that beta-blockers be maintained, as well as intravenous magnesium replacement to avoid hypomagnesemia, with rigorous postoperative AF monitoring [22]. However, it should be taken into account that beta-blockers may reduce the risk of AF in the postoperative period after noncardiac surgery, but this effect is achieved at the expense of an increased risk of bradycardia, and hypotension [23, 24]. Hypotension, on the other hand, may affect graft function.

The increased risk of death and graft rejection in individuals with NOAF shows that underlying causes may play a role in the development of atrial fibrillation in these patients. Identifying these characteristics might improve outcomes for post-LT NOAF patients.

There have also been several hypotheses proposed as to why LT increases the frequency of NOAF throughout the postoperative period. For example, traditional postoperative hemodynamic challenges may result in NOAF due either to hemodynamic instability or inotropic hemodynamic support [25]. NOAF after LT could be associated with autonomic dysfunction, surgical stress, increased catechola-

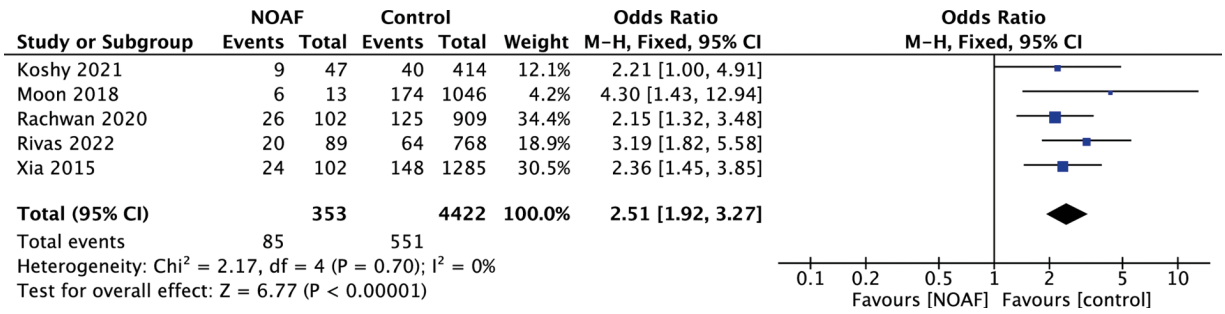

FIGURE 2. Forest plot of return of mortality among patients with and without new-onset atrial fibrillation (NOAF) after liver transplant. The center of each square represents the odds ratio (OR) for individual trials, and the corresponding horizontal line stands for a 95% confidence interval (CI). The diamonds represent pooled results

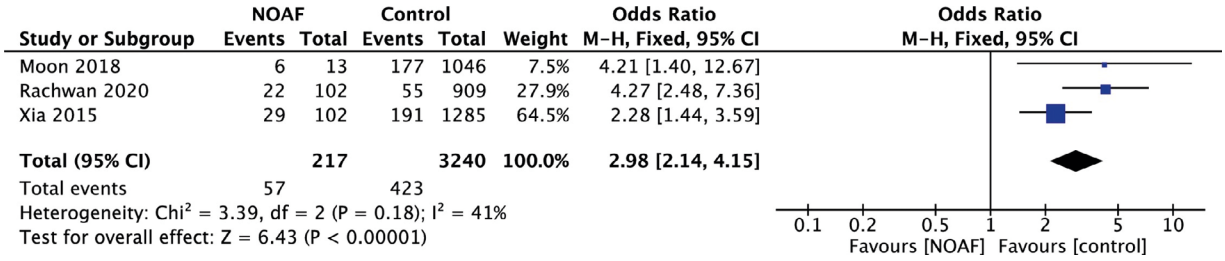

FIGURE 3. Forest plot of return of graft rejection among patients with and without new-onset atrial fibrillation (NOAF) after liver transplant. The center of each square represents the odds ratio (OR) for individual trials, and the corresponding horizontal line stands for a 95% confidence interval (CI). The diamonds represent pooled results

mine levels, pre-existing pericardial inflammation, and cardiac malfunction [26]. Acidosis, hypo/hyperkalemia, hypocalcemia, hypoglycemia, hypothermia, a higher MELD score, and fulminant hepatic failure after LT may also result in NOAF [14]. Hypomagnesemia is a well-known cause of cardiac arrhythmias [27]. Further, massive bleeding, hypotension, and high-dose catecholamine use after LT can all contribute to increased NOAF risk; hence, NOAF is more likely during the anhepatic period because of the increased need for inotropic support during this phase [28]. The mentioned earlier sudden influx of blood from the inferior vena cava with a mechanical stretch of the atria and hypothermia caused by the influx of cold preservation solution should be taken into account as a stressor triggering AF during the intra-operative period [18].

Finally, the leading cause of long-term mortality in patients with LT is cardiovascular complications, which, other than AF, may include heart failure and acute myocardial infarction. These complications are predominantly driven by the development of metabolic syndrome after LT, and many studies have been conducted to determine the involvement of metabolic syndrome in the development of atrial fibrillation [29]. Further, immunosuppressive medicine increases the risk of developing insulin resistance, which also contributes to metabolic syndrome [30]. Lastly, certain cirrhosis-specific cardiac illnesses, such as the well-known condition known as congestive hepatopathy, play a crucial arrhythmogenesis function as a substrate for the etiology of NOAF prior to transplantation [31, 32].

Limitations

The fact that only observational studies involving a small number of patients were included in our investigation is the first significant limitation of our findings. However, it is important to highlight that this is a rather specialized subject that makes the preparation of randomized trials exceptionally challenging, particularly in the case of post-LT NOAF. Furthermore, we are unable to rule out the possibility that some of the patients in the studies experienced asymptomatic NOAF, which may not have been diagnosed since there was a shortage of diagnostics. In some studies, opportunistic screening was used to determine NOAF. Thus, only patients located in the critical care unit, or those on the general ward with cardiac risk factors or symptoms who were being constantly monitored on telemetry after LT surgery would be identified, as was the case

in several of the studies. Therefore, it is impossible to rule out the possibility of incomplete records for those who had minimal symptoms or were asymptomatic. This is likely to be an underestimate of the real rate. However, because our meta-analysis indicates that liver transplant patients with NOAF may have a higher risk of mortality and graft rejection, additional research, preferably population-based or national database studies, is required to assess the need for routine testing and determine its potential impact on outcomes.

CONCLUSIONS

Post-LT NOAF is associated with increased mortality and a higher risk of graft rejection. It is likely that the development of a standard procedure for early identification of NOAF, as well as recommendations for specific treatment targeted at avoiding the impacts of the illness, could provide a mortality reduction and an increased rate of successful LT. Multicenter trials on larger groups are needed to provide a broader exploration of post-LT NOAF and its consequences.

Article information and declarations

Data availability statement

The data that support the findings of this study are available on request from the corresponding author (L.S.).

Author contributions

Conceptualization, F.C. and L.S.; methodology, F.C. and L.S.; software, L.S., N.L.B. and F.C.; validation, T.T., Z.R., F.W.P. and L.S.; formal analysis, F.C. and L.S.; investigation, F.C., N.L.B., M.P. and L.S.; resources, F.C. and L.S.; data curation, M.P., I.J. and L.S.; writing — original draft preparation, F.C., M.P., Z.R., F.W.P. and L.S.; writing — review and editing, F.C., L.S., M.P., J.R., I.J., T.T., K.J., N.L.B., Z.R. and F.W.P; visualization, L.S. and F.C.; supervision, F.W.P. and L.S.; project administration, F.C., F.W.P. and L.S.; All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Acknowledgments

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 23–35
DOI: 10.5603/demj.97463

ISSN 2451–4691, e-ISSN 2543–5957

EFFECTS OF OCCUPATIONAL SAFETY PERFORMANCE ON WORK ENGAGEMENT OF EMERGENCY WORKERS: MEDIATING ROLE OF JOB SATISFACTION

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ABSTRACT

INTRODUCTION: The issue of occupational health and safety (O.H.S.) is paramount for emergency personnel who are consistently exposed to high-stress situations. Ensuring these workers feel safe, not only physically but mentally and socially, is increasingly recognized as crucial. With the directives of the International Labor Organization (I.L.O.) and pertinent legal regulations, the emphasis on occupational health is surging. Recently, low motivation and inefficiency in emergency workers have begun to manifest as organizational issues. Safe and healthy working environments for emergency personnel are imperative to minimize these problems and reduce work accidents and occupational diseases. This study posits that the occupational safety performance of emergency workers will augment their work engagement and job satisfaction. Additionally, it is hypothesized that job satisfaction will mediate the relationship between occupational safety performance and work engagement.

MATERIAL AND METHODS: A model delineating the relationship between occupational safety performance, job satisfaction, and work engagement among emergency personnel was established. Data were collected from 385 emergency personnel based in Istanbul, Turkiye, to assess their perceptions of occupational safety performance, work engagement, and job satisfaction. Using the snowball sampling method, a questionnaire comprising scales for occupational safety performance, job satisfaction, work engagement, and demographic questions was distributed.

RESULTS: Among emergency personnel, occupational safety performance exhibited a significant positive influence on both job satisfaction and work engagement. Furthermore, job satisfaction had a notable positive effect on work engagement. Crucially, the research indicated that job satisfaction mediated the relationship between occupational safety performance and work engagement.

CONCLUSIONS: This study shows that improving emergency sector occupational safety can boost employee engagement and work satisfaction. Job satisfaction mediates occupational safety performance and work engagement, underlining its importance in emergency workforces. These findings are essential for creating a secure and inspiring workplace for emergency workers and driving policies that emphasize their well-being.

KEYWORDS: cultural safety; job satisfaction; occupational safety performance; occupational health and safety; occupational psychology

Disaster Emerg Med J 2024; 9(1): 23–35

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Received: 17.09.2023 Accepted: 6.10.2023 Early publication date: 10.11.2023

INTRODUCTION

The International Labor Organization (I.L.O.) estimates that around 2.3 million women and men worldwide succumb to work-related accidents or illnesses each year. This number corresponds to more than 6000 deaths every day. The I.L.O. updates these estimates periodically, and the updates point to an increase in accidents and occupational diseases [1]. Occupational accidents and injuries can cause significant pain and suffering [2, 3]. Furthermore, labor markets can create huge financial burdens for wider economies and organizations. Due to the strong relationship between occupational safety performance and occupational accidents, commercial and academic interest in occupational safety performance has gained momentum recently [4]. Employers, O.S.H. professionals, and social politicians should focus on improving occupational safety performance as a way to improve workplace safety [5]. However, in order to improve occupational safety performance and accordingly, reduce occupational accidents and injuries, it is necessary to first understand the factors affecting occupational safety performance.

Strategic management of human resources it is very important for obtaining various organizational and individual results, including the behavior of employees [6]. For this reason, it is useful to investigate possible factors affecting occupational safety performance [7, 8]. Many studies carried out in today's organizations are based on the fact that when decent working conditions are offered for employees, it will provide many benefits not only to employees but also to organizations. Based on the studies on occupational health and safety and job satisfaction, it has been found that O.H.S. has a positive effect on job satisfaction [9, 10].

Research has shown that there is a positive relationship between the measured level of employee engagement and business unit outcomes such as higher productivity, better quality, lower employee turnover, greater customer satisfaction, and increased profitability [11, 12]. In addition, there are studies in the literature that reveal the relationship between occupational safety performance and employee engagement [13, 14]. In these studies, it is seen that people who experience fewer work accidents have more work engagement. In this regard, Molson Coors beverage company saved 1.7 million dollars in safety costs by strengthening employee loyalty [15]. Based on this outcome, it could be argued that employees' work engagement will be higher in organizations that provide a physically, cognitively, and emotionally healthy and safe working environment.

This study aimed to determine the mediating role of job satisfaction in the relationship between occupational safety performance and work engagement, which will provide individual, organizational, and macro-level development competition. The conceptual structure, in which job satisfaction constitutes a mediating variable, was theorized and analyzed with the structural equation model. This research, in addition to understanding the advantages of having employees with high occupational safety performance and work engagement, also provides interesting information that will help to understand the advantages of using the power of job satisfaction to be competitive and profitable.

Literature review and hypotheses

As with the safety climate, which is considered a subset of the organizational climate, occupational safety performance is also considered a sub-system of organizational performance. However, it is considered that the safety climate is among the antecedents of occupational safety performance [16]. Occupational safety performance components represent the main dimensions of employees' behaviors related to occupational safety activities [17–19]. General safety performance, on the other hand, refers to the actions or behaviors exhibited for the improvement of the health and safety of individuals, employees, customers, the public, and the environment [20].

Work engagement theory argues that increasing the performance of employees can be achieved by them devoting themselves to their work through emotional investment [21–23]. In work engagement, people express themselves physically, cognitively, and emotionally during role performances [22]. Work engagement is an independent, pervasive, positive, and satisfying psychological state characterized by energy, focus, and immersion in work [24]. Employees with high work engagement have more energy and interest in the job. Therefore, they do not care about the time spent on work [25–27]. As a natural consequence of this, they can continue to work efficiently for longer hours. Bakker, Albrecht, and Leiter [28] define work engagement as a high level of work-oriented energy and work participation. At this point, participation is a motivational

concept [29, 30]. It focuses on the internalization of the missions of individuals and organizations [31]. Work engagement is an attitudinal-motivational construct derived from organizational behavior research. Work engagement and motivation can be thought of as a reflection of employees' reactions to the "fit" between technical and social systems. For this reason, positive psychological states of employees, such as work engagement, have the potential to increase motivation.

Although work engagement has received wide attention in research, its relationship with the concept of safety has rarely been empirically investigated [32]. Kahn [22], safety and work engagement have been associated as structures that affect people's interaction with their work in the presence of safe working conditions, and that employees leave their jobs personally in the absence of safe working conditions. "Personal participation", closely related to work engagement, is considered risky when situations are inconsistent and unpredictable. According to Kahn, people will feel safe, when they have no problems with their commitment to work.

Accordingly, people's work engagements are shaped by their perceptions of safety. Harter et al. [13] in his study found that units with lower employee engagement experienced 62% more adverse safety events. In addition, the literature found that employees with high work engagement were five to seven times less likely to experience a safety incident than others, and the average cost of any safety incident among employees with high work engagement was approximately one-fourth, compared to employees with low work engagement. There are studies that found that the rate is lower [11, 12, 15].

It is known that there is an internal relationship between job commitment and job satisfaction. Researchers have compared employees' satisfaction with the organizational environment and organizational management and found that their satisfaction with job characteristics is an important factor affecting job engagement [33]. Vroom [34] defined job satisfaction as "positive attitudes towards work". Hoppock [35] defines job satisfaction as the combination of physiological, psychological, and environmental factors that cause the individual to express satisfaction with their job. Job satisfaction is significantly related to the satisfaction of employees with their jobs and their productive work [36, 37]. In this context, employees who feel safe will be more motivated for high job satisfaction. On the other hand, it is known that O.H.S. practices have a positive effect on the job satisfaction of employees [9, 10, 38–40]. Ajala [41] analyzed the impact of the workplace environment on employee well-being and productivity. He found that workplace characteristics and good communication networks in the workplace affect employee well-being, health, performance, and productivity. Ayim and Gyekye [42] examined the relationship between workers' workplace safety, job satisfaction, and accident frequency, a positive relationship was found between job satisfaction and safety climate. Sembe and Ayuo [43], occupational health and safety management practices increase job satisfaction among employees. Tengilimoğlu et al. [44] found a significant relationship between safety performance and job satisfaction. Emergency workers, such as paramedics, firefighters, and emergency room staff, frequently operate in high-stress environments, where the risk of occupational hazards is considerably elevated [45–54]. These individuals often encounter traumatic situations, unpredictable hours, and demanding physical conditions, all of which can substantially impact their occupational safety and overall well-being. Given these distinct challenges, understanding safety performance and its implications for such a workforce becomes even more vital. Occupational accidents and injuries, apart from causing immense personal anguish, can also impose substantial financial burdens on economies and organizations. Given the clear link between occupational safety performance and accidents, there's been a surge in both commercial and academic interest in understanding safety performance, particularly in high-risk sectors like emergency services [55–58].

Based on the literature and empirical studies [59–63], it is suggested that occupational safety performance affects work engagement and job satisfaction is the mediator variable in this interaction. The hypotheses and model (Fig. 1) created in the light of the reasons mentioned are as follows:

- H1: occupational safety performance has a positive effect on work engagement;
- H2: occupational safety performance has a positive effect on job satisfaction;
- H3: job satisfaction has a positive effect on work engagement;
- H4: job satisfaction has a mediating role in the relationship between occupational safety performance and work engagement.

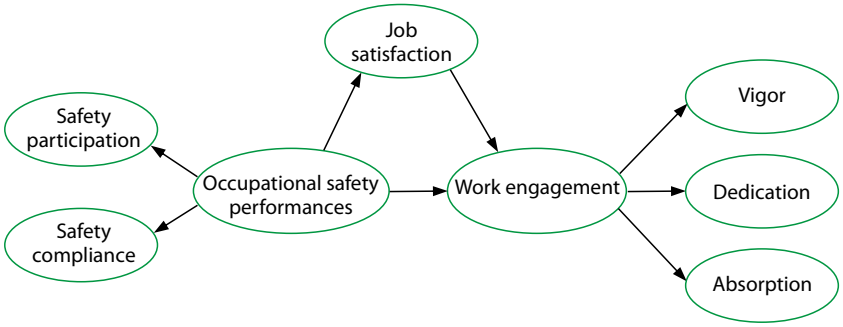

FIGURE 1. Conceptual framework

MATERIAL AND METHODS

Study procedure and participants

This study aimed to assess the impact of occupational safety performance on work engagement and job satisfaction of healthcare professionals, specifically doctors and paramedics, within the emergency sector. We also examined the mediating role of job satisfaction in the relationship between occupational safety performance and work engagement. The procedure for this study was approved by Istanbul Aydin University (Reference number: 2022/03). Data for this research was collected through an online questionnaire hosted on Google Forms. The target population comprised a representative sample of emergency healthcare professionals, including doctors and paramedics, based in Istanbul, Turkey. Employing the "Specific Sampling Method" ensured that the participants in the study accurately represented the broader emergency healthcare community.

The questionnaire used to obtain the data consists of four parts. In the first part, there are demographic questions, followed by questions consisting of "job safety performance", "work engagement" and "job satisfaction" scales, respectively. The answers were taken on a 5-point Likert scale (1 = I strongly disagree, 5 = I strongly agree). Information on the scales used in the study is given below.

Occupational Safety Performance Scale: The scale, which was created by Vinodkumar and Bhasi [64], and whose Turkish validity and reliability studies were conducted by Ekingen [19], measures "safety involvement" (4 items) and "safety compliance" (4 items) dimensions.

Job Satisfaction Scale: Başol and Çömlekçi [65] conducted the Turkish validity-reliability study of the job satisfaction scale developed by Brayfield and Rothe [66], and shortened by Judge et al. [67]. The scale consists of a single factor.

Work Engagement Scale: The Turkish adaptation of the scale developed by Schaufeli et al. [18], was made by Eryılmaz and Doğan [68] and Özkalp and Meydan [63], and the final version was shaped by Güler et al. [23]. An alternative version of the UWES-6 form was used. The scale has three sub-dimensions, each consisting of two items: being energetic, devotion and immersion.

Statistical analyses

In this study, a method consisting of two stages, the measurement model and the structural model, was applied [70]. Confirmatory factor analysis was used to test the measurement model, and structural equation model analysis was used to test the structural model. Structural equation modeling is a statistical approach used to test and predict causal relationships and verify structural theories [71]. By applying the structural equation model analysis, the structural relationships between occupational safety performance, work engagement, and job satisfaction, were examined, and the mediating role of job satisfaction was tested. In order to discuss the intermediary role, the following conditions must be met; i) the total effect of the independent variable on the dependent variable must be statistically significant, ii) the observed indirect effect must be statistically significant, and iii) tV.A.F. calculated Variance Accounted For (VAF = indirect effect/total effect*100) value must be greater tV.A.F. 20% [72]. Variance Accounted For value; If it is over 80%, it is considered full mediation, between 20% and 80% partial mediation, and below 20% there is no mediation role.

Some assumptions were checked before the analysis. Skewness and kurtosis coefficients in the range of ± 1.5 indicate that the data have a normal distribution [73, 74]. The calculated coefficients ($-1.27 \leq$ Skewness ≤ -0.97, $0.46 \leq$ Kurtosis ≤ 1.24)

showed that the data used in this study had a normal distribution. According to the Cook distance values calculated for the research data, there are no multivariate extreme values in the data set (Cook V.I.F.tance < 1). VIF > 10 values indicate multicollinearity [75]. The high eV.I.F. calculated VIF value was 3.20, and this value showed that there was no multicollinearity between the variables. Analyses were performed using the IBM SPSS AMOS 24.0 statistical package program.

RESULTS

Of the 400 healthcare professionals in the emergency sector who were approached for the study, 385 participated, yielding a response rate of 96.25% (Tab. 1). This sample comprised a mix of genders and roles within the emergency healthcare sector. Out of the 385 participants, 235 were doctors, accounting for approximately 61% of the sample. Emergency doctors are typically responsible for assessing, diagnosing, and treating patients who require immediate medical attention, whether it is due to injury or acute illness. The remaining 150 participants were paramedics, making up roughly 39% of the sample. Paramedics are trained healthcare professionals who provide emergency on-the-spot treatment and are vital for stabilizing and transporting patients to hospitals. They often work in ambulances and are among the first responders in emergencies.

Measurement model

Confirmatory factor analysis (C.F.A.) was applied to test the measurement model. Calculated fit values (χ^2 = 345.00; df = 136; χ^2 /df = 2.54; GFI = 0.88; AGFI = 0.91; TLI = 0.96; CFI = 0.97; IFI = 0.97; SRMR = 0.04; RMSEA = 0.06), showed that the data were agreeable with the model tested [76–78]. The factor loads of the items in the tested model ranged from 0.69 to 0.95. Calculated factor loads are statistically significant at each 0.001 level (Tab. 2).

By calculating the Cronbach Alpha coefficients, the reliability levels of the scales based on internal consistency were examined. The alpha coefficients calculated for the factors took values between 0.88 and 0.94. Alpha coefficients of 0.70 and higher indicate that the reliability based on internal consistency is at a sufficient level [76–79]. In order to examine the convergence and divergence validity of the factors in the measurement model, Composite Reliability (C.R.), Average Variance Extracted (AVE), Maximum Shared Variance (MSV), Maximal Reliability [MaxR(H)] values, were calculated. The obtained values are shown in Table 2.

The values calculated to examine the discriminant and convergent validity are given in Table 2. Providing C.R. > 0.70 and AVE > 0.50 conditions indicates that the internal reliability criteria are met. Meeting the C.R. > AVE condition indicates that convergent validity is achieved [80]. The AVE > MSV condition was largely met for the factors, indicating that discriminant validity was achieved. Finally, it was observed that the MaxR(H) > C.R. condition was met. This situation supports that discriminant validity is provided [81]. As a result, evidence showed that the six-factor measurement model was validated. It has been understood that the reliability of the factors based on internal consistency is sufficient. It was observed that discriminant and convergent validity were provided between the factors.

Structural model

Before testing the structural model, the relationships between occupational safety performance, work engagement, and job satisfaction were examined by calculating Pearson correlation coefficients. The obtained coefficients are shown in Table 3.

When Table 3 is examined, Safety participation scores and Vigor (r = 0.512; p < 0.01), Dedication (r = 0.574; p < 0.01), Absorption (r = 0.453; p < 0.01), W.E.S. Total (There are moderate positive correlations between r = 0.586; p < 0.01) and Job satisfaction (r = 0.554; p < 0.01) scores.

Vigor (r = 0.516; p < 0.01), Dedication (r = 0.589; p < 0.01), Absorption (r = 0.482; p < 0.W.E.S., WES Total (r = 0.604; There are moderate positive correlations between p < 0.01) and Job satisfaction (r = 0.574; p < 0.0 O.S.P.s cores. OSP total scores with Vigor (r = 0.540; p < 0.01), Dedication (r = 0.611; p < 0.01), Absorption (r = 0.49 W.E.S; p < 0.01), WES Total (r = 0.625; There are moderate positive correlations between p < 0.01) and Job satisfaction (r = 0.593; p < 0.01) scores. Job satisfaction scores with Vigor (r = 0.746; p < 0.01), Dedication (r = 0.W.E.S; p < 0.01), Absorption (r = = 0.591; p < 0.01), and WES Total (r = 0.807; There are moderate and high-level positive correlations between p < 0.01 scores.

Figure 3 shows the structural model tested. In the model, occupational safety performance is the independent variable, work engagement is the dependent variable, and job satisfaction is the medi-

Table 1. Distribution of participants by diagnostic characteristics

Variable	Level	n	[%]
Gender	Male	210	54.5
	Woman	175	45.5
Age	18–24	131	34.0
	25–30	93	24.2
	31–40	106	27.5
	41–50	47	12.2
	51 and above	8	2.1
Marital status	Single	240	62.3
	Married	145	37.7
Graduation	High school	19	4.9
	Associate degree	153	39.7
	License	101	26.2
	Degree	92	23.9
	Doctorate	20	5.2
Total working time	Less than 1 year	81	21.0
	1–5 years	120	31.2
	6–10 years	76	19.7
	11–15 years	58	15.1
	16 years and above	50	13.0
Sector	Education	87	22.6
	Service	155	40.3
	Manufacturing industry	46	11.9
	Build	82	21.3
	Tunnel–metro construction	15	3.9
Task	I am not an occupational safety expert/technician	0	0
	I am an occupational safety specialist/technician	385	100.0

ating variable. Fit values calculated by testing the model (χ^2 = 354.69; df = 143; χ^2/df = 2.48; GFI = 0.91; AGFI = 0.88; TLI = 0.96; CFI = 0.97; IFI = 0.97; SRMR = 0.04; RMSEA = 0.06) showed that the data were acceptable with the model [56–58]. Total, direct, and indirect effects in the tested model are shown in Table 4.

Table 4 shows standardized estimates, standard errors, p values, and confidence intervals. When the total effect value was examined, the predictive power of occupational safety performance was 0.69 [95% confidence interval (CI): 0.59, 0.77, $p < 0.001$]. According to this result, the H1 hypothesis was confirmed. Considering the direct effect values, the power of job safety performance to directly predict work engagement was 0.20 (95% CI: 0.06, 0.32, $p < 0.001$), and the power to directly predict job satisfaction was 0.63 (95% CI: 0.52, 0.72, $p < 0.001$). The power of job satisfaction to directly predict work engagement was 0.78 (95% CI; 0.66, 0.90, $p < 0.001$). According to the results obtained, H2 and H3 hypotheses were confirmed.

When the indirect effect value was examined, the power of occupational safety performance to indirectly predict work engagement was 0.49 (95% CI: 0.39, 0.61, $p < 0.01$). A large proportion of the overall impact of occupational safety performance on work engagement is through job satisfaction. According to the results obtained, the H4 hypothesis was confirmed. Job satisfaction partially mediates between occupational safety performance and work engagement (VAF = 71%).

In the model in Figure 3, occupational safety performance and job satisfaction explained 85% of

Table 2. Validity and reliability analysis results

Variable	Item no.	Factor load	Cronbach Alpha	CR	AVE	MSV	MaxR (H)
Vigor	We1	0.94*	0.94	0.93	0.89	0.65	0.94
	We2	0.95*					
Dedication	We3	0.94*	0.93	0.92	0.86	0.72	0.93
	We4	0.92*					
Absorption	We5	0.95*	0.90	0.90	0.82	0.51	0.92
	We6	0.86*					
Safety participation	Osp1	0.86*	0.93	0.92	0.76	0.84	0.93
	Osp2	0.89*					
	Osp3	0.89*					
	Osp4	0.86*					
Safety compliance	Osp5	0.69*	0.88	0.88	0.64	0.84	0.89
	Osp6	0.86*					
	Osp7	0.84*					
	Osp8	0.80*					
Job satisfaction	Js1	0.81*	0.92	0.92	0.70	0.72	0.93
	Js2	0.78*					
	Js3	0.82*					
	Js4	0.88*					
	Js5	0.87*					

*p < 0.001; Osp — occupational safety performances; We — work engagement; Js — job satisfaction

Table 3. Pearson correlation coefficients

	Variables	1.	2.	3.	4.	5.	6.	7.	8.
1.	Safety participation	1							
2.	Safety compliance	0.812*	1						
3.	OSP total	0.951*	0.953*	1					
4.	Vigor	0.512*	0.516*	0.540*	1				
5.	Dedication	0.574*	0.589*	0.611*	0.755*	1			
6.	Absorption	0.453*	0.482*	0.492*	0.545*	0.649*	1		
7.	WES total	0.586*	0.604*	0.625*	0.870*	0.915*	0.841*	1	
8.	Job satisfaction	0.554*	0.574*	0.593*	0.746*	0.786*	0.591*	0.807*	1
	M	17.27	16.78	34.05	7.78	8.06	7.71	23.56	19.14
	SD	3.20	3.28	6.17	1.93	2.00	2.06	5.23	4.76

*p < 0.01; n = 385; OSP — Occupational Safety Performances; WES — Work Engagement Scale

the variation in work engagement (R^2 = 0.85). This result showed that occupational safety performance and job satisfaction significantly affected work engagement (f^2 = 5.67). Occupational safety performance explained 40% of the change in job satisfaction (R^2 = 0.40). Occupational safety performance significantly affects job satisfaction (f^2 = 0.67).

DISCUSSION

Our findings show that in high-pressure environments like emergency healthcare, ensuring the safety and well-being of personnel is paramount. Emergency personnel — including doctors and paramedics — often find themselves at the frontline of critical situations, where the risks and stakes are

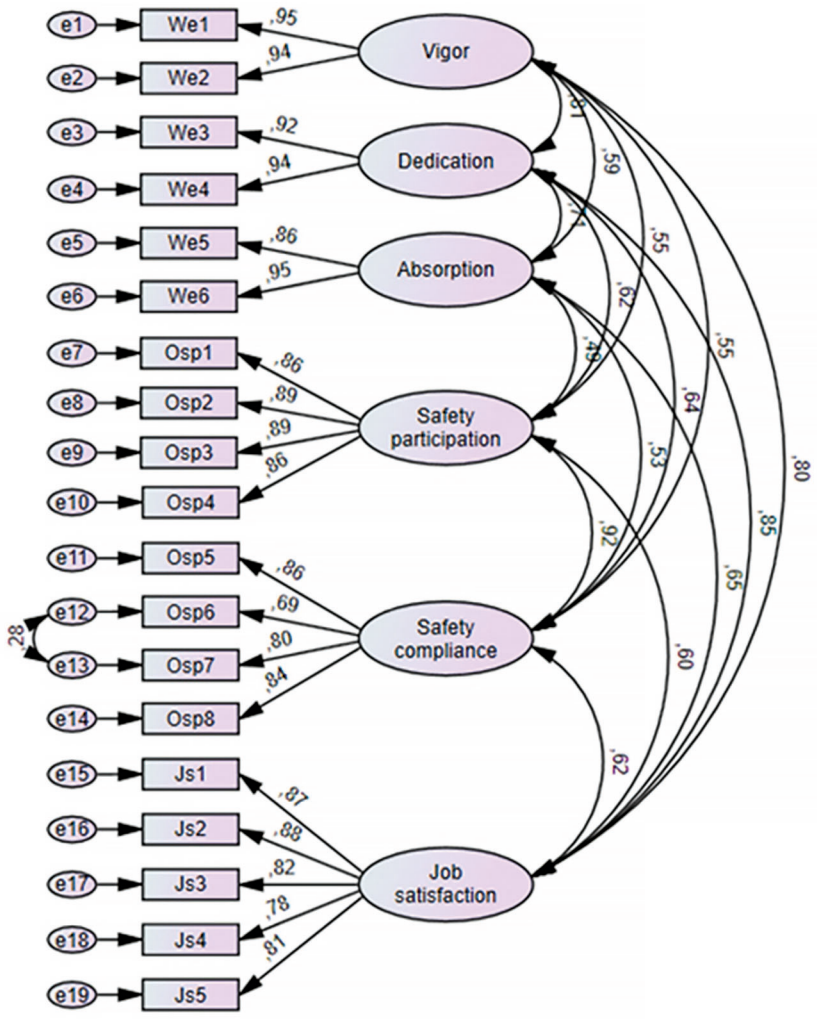

FIGURE 2. Measurement pattern, $\chi^2 = 345.00$; SD = 136; $p < 0.01$

significant. This is where occupational safety takes on heightened significance.

In this research focusing on emergency healthcare professionals, a model delineating the relationship between occupational safety performance and work engagement, with job satisfaction playing a mediating role, was evaluated. Analysis revealed a moderate positive correlation between occupational safety performance, work engagement ($r = 0.625$; $p < 0.01$), and job satisfaction ($r = 0.593$; $p < 0.01$). A notably high correlation was observed between job satisfaction and work engagement ($r = 0.807$; $p < 0.01$).

Structural equation model analysis tested the developed model. The findings indicated that 85% of the variance in work engagement could be explained by occupational safety performance and job satisfaction, signifying a substantial effect. This underscores the intertwined nature of these aspects in the emergency healthcare sector. It suggests that fostering a robust safety culture enhances a sense of occupational security among employees and amplifies their job satisfaction and work engagement.

Such findings accentuate that ensuring occupational safety isn't merely about adhering to legal obligations; it fosters positive outcomes like heightened work engagement and elevated job satisfaction. When engaged and satisfied, emergency personnel are better positioned to deliver efficient care, ultimately benefiting the healthcare institutions they represent [82–87].

Several key takeaways from this study include:

— human capital is vital in high-stress sectors like emergency healthcare. Understanding the intricate dynamics of the workplace is essential to ensure effective patient care;
— establishing a pervasive safety culture is pivotal. Emergency personnel must feel secure in their environment to deliver optimal care;

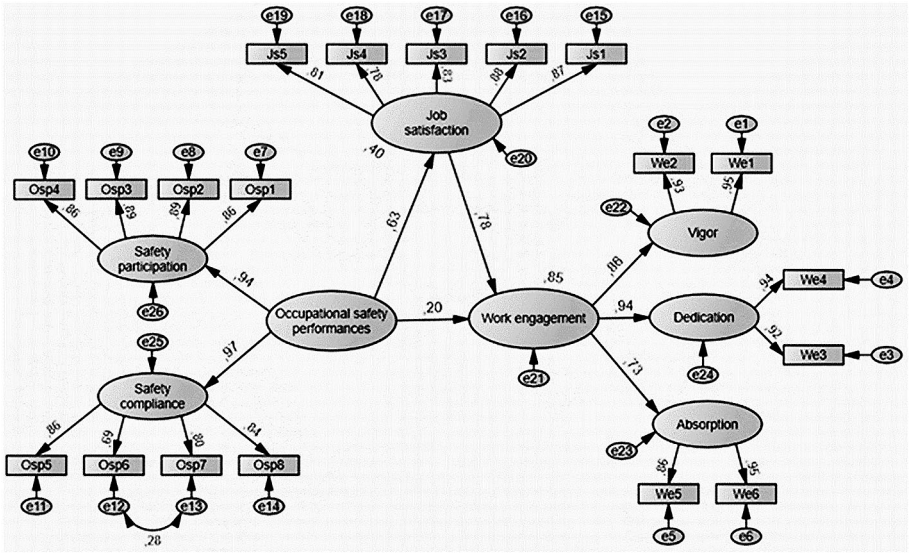

FIGURE 3. The structural relationship among occupational safety performances, work engagement and job satisfaction, χ^2 =354.69; SD = 143; p < 0.01

Table 4. Standardized regression weights

Effect				Outcome variable	β	SE	p value	95% CI	
								BootLLC	BootULCI
Total Effect									
Osp	→			We	0.69	0.05	< 0.001	0.59	0.77
Direct Effects									
Osp	→			We	0.20	0.07	< 0.001	0.06	0.32
Osp	→			Jp	0.63	0.05	< 0.001	0.52	0.72
Jp	→			We	0.78	0.06	< 0.001	0.66	0.90
Indirect Effect									
Osp	→	Js	→	We	0.49	0.06	< 0.001	0.39	0.61

Osp — occupational safety performances; We — work engagement; Jp — job satisfaction; CI — confidence interval

— engaging occupational safety experts, amplifying their influence, and heeding their advice could be pivotal in nurturing a holistic safety culture;
— employee representation in Occupational Health and Safety (OHS) boards and considering their inputs in decision-making processes can enhance job satisfaction and overall well-being.

However, this study, while invaluable, is not without its limitations. Future research might benefit from integrating control, moderator, or mediator variables for a more comprehensive understanding. The addition of individual attributes to the model can provide a deeper, more nuanced insight into the intricate dynamics of occupational safety, job satisfaction, and work engagement among emergency healthcare professionals [88–92].

The healthcare environment, especially the emergency sector, is a highly stressful workplace where the risks of burnout, work-related stress, and incidents of workplace violence are high. The results of this study can be vitally important for occupational health physicians and occupational health services to address these challenges.

By understanding the relationship between occupational safety performance, work engagement, and job satisfaction, occupational health services can better devise strategies to bolster safety and well-being in emergency settings. Occupational

health physicians can design interventions specifically targeting emergency personnel. These might include stress-reduction workshops, training on coping mechanisms, or team-building exercises that address unique challenges faced by this group. By advocating for a robust safety culture, occupational health services can stress the importance of an environment, where healthcare professionals feel physically, mentally, and emotionally secure. This can lead to reduced incidents of workplace violence and increased job satisfaction. Establishing precise feedback mechanisms where emergency personnel can communicate their safety concerns or suggestions can ensure they feel heard and valued, thus increasing job satisfaction and engagement. Recognizing the emotional toll that the emergency environment can take, it might be beneficial to introduce well-being and resilience-building programs tailored to the specific needs of emergency healthcare workers. By understanding the factors that enhance job satisfaction and work engagement, measures can be taken to reduce potential stressors. This might involve adjusting workloads, ensuring adequate break times, or providing mental health support. With the knowledge that increased job satisfaction and work engagement can reduce the likelihood of workplace incidents, occupational health services can introduce training programs that equip emergency personnel with the tools to de-escalate potentially violent situations or cope with the aftermath.

CONCLUSIONS

Summing up, by integrating the findings of this study, occupational health services and physicians can pave the way for a safer, more engaged, and more satisfied emergency healthcare workforce. This benefits the professionals themselves, the patients they serve, and the healthcare system at large.

Article information and declarations

Author contributions

Conceptualization, D.Ç.T.; data collection, Z.F.O and A.Y.; laying out the methodology and statistical analysis, G.C.A. and Z.F.O. Writing-reviewing-editing, supervision and validation: M.Y., F.C., L.S. All authors acknowledge and declare that they have contributed equally to resources, data curation, original draft preparation, review and editing. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Institutional review board statement

Ethics committee approval of the study was obtained from Istanbul Aydin University/Turkey Ethics Committee.

Informed consent statement

Informed consent statement/voluntary participant consent texts were collected and archived from the study participants via Google form.

Data availability statement

Data will be provided by the corresponding author at the reasonable request of the corresponding author (F.C.). The corresponding author agrees and undertakes to share the raw data.

Conflict of interest

The authors declare no conflict of interest.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 36–41
DOI: 10.5603/demj.96730

ISSN 2451–4691, e-ISSN 2543–5957

AN OBSERVATIONAL STUDY OF FIRST AID KNOWLEDGE AND PRACTICE FOR BURN INJURY IN RURAL INDONESIA

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ABSTRACT

INTRODUCTION: Burn injuries in rural communities necessitate an accurate assessment of burn size and severity to decide if they may be treated in a community hospital or require care at a burn center. Proper treatment of burns is crucial as they can result in death or disability with long-lasting effects. In order to reduce disability and prevent deaths, it is crucial to know and practice correct first aid methods for treating burns in rural populations. This study sought to survey knowledge and practice of first aid in burn-related injuries amongst the rural population in Indonesia.

MATERIAL AND METHODS: The study conducted was a descriptive cross-sectional study. It involved 151 respondents residing in a rural area of Eastern Indonesia. A self-administered questionnaire assessed their knowledge and practice of first aid for burn-related injuries. Data were analyzed using univariate analysis.

RESULTS: Out of the 151 respondents surveyed, 76.2% were unfamiliar with the recommended burn-related injury first-aid practices. Half of the respondents (59.4%) indicated using toothpaste as their first-aid treatment for burn-related injuries.

CONCLUSIONS: This current study showed insufficient knowledge and practice of first aid in burn-related injuries amongst the rural population in Eastern Indonesia.

KEYWORDS: burns; emergency treatment; first aid; knowledge; rural population

Disaster Emerg Med J 2024; 9(1): 36–41

INTRODUCTION

A burn is an injury induced by applying dry heat to the body surface, such as flames, radiant heat, or hot objects [1]. Burns is a significant public health problem that ranks fourth among all injuries worldwide [2]. According to the World Health Organization (WHO), 180,000 deaths yearly occur due to burns. In high-income countries, the death rate from burns has decreased. On the other hand, in countries with moderate incomes, the mortality rate due to burns has increased by over sevenfold. [3]. Based on the Indonesia National Survey Data or Riskesdas (2013), in Indonesia, the occurrence of burns currently stands at 0.7% and is projected to rise to 1.3% in 2018 [5]. The highest number of burn injuries occur in developing countries; among women, 80% of burns occur in the home environment, and 20% occur in the workplace [6, 7].

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Received: 29.07.2023 Accepted: 10.10.2023 Early publication date: 14.11.2023

In Indonesia, studies have revealed that parental awareness of burns first aid is low, but few treatments to enhance this knowledge have been studied [8]. Although rural areas in Indonesia are home to 44% of the country's population, information on burns in Indonesia is severely constrained, as it is primarily available only in national referral centers within Indonesia's most prominent cities [9]. The consequences of mishandling first aid for burns are damaging. It is important to note that mishandling first aid for burns can have fatal consequences, which many individuals may not know [10, 11]. The community's lack of knowledge often leads to using toothpaste, soy sauce, coconut oil, butter, and honey for treating burns [12, 13].

Burn injuries, including smoking, electrical appliances, cooking, water heating, and chemical products, are common in residential environments [14]. Knowledge about proper first aid for burns is necessary for the general public or ordinary individuals due to the common occurrence of burns daily. Having accurate knowledge about first aid for burns will reduce the overall impact of the injury [15]. It is crucial to examine the understanding and application of first aid for burn injuries among rural individuals in Indonesia, recognizing the crucial role stay-at-home mothers play as first responders in such incidents that commonly happen within their homes.

MATERIAL AND METHODS

Study design, setting, and respondents

We conducted a cross-sectional, observational study due to their ability to mirror populations and conditions encountered in everyday circumstances. This approach would facilitate the inclusion of substantial number of patients, thereby enabling the evaluation of treatment effects within a more heterogeneous populace [16]. The study area covered a rural area of Awu Village, Central Sulawesi, Indonesia. This small rural area covers 3.00 km^2 and is inhabited by an estimated population of approximately 1.144 individuals.

We used a purposive sampling method with the following inclusion criteria: consenting housewives aged 18 and above and having prior experience in treating burn injuries. The sample consists of 151 housewives selected using a purposive sampling technique.

Instrument and data collection

We obtained sociodemographic information from the questionnaire, such as age and education level. To evaluate knowledge of burns, we utilized a self-administered questionnaire created by Lam et al. [17]. Afterward, we converted the questionnaire into Indonesian from English. Respondents were requested to fill out the questionnaire within a time frame of around 10–15 minutes. The questionnaire in this study was split into two sections. The initial section of the questionnaire consists of five questions, each offering three answer choices. A score of 1 is awarded for each correct answer the respondent provided. If the respondent answers incorrectly, they will receive a score of 0. The score obtained by the respondent can range from 0 to a maximum of 5. The objective of the second part of the questionnaire is to investigate the respondents' experiences. It consists of four statement items, allowing them to select multiple answers if applicable.

Data analysis

The data on the knowledge and practice of first aid in burn-related injuries was analyzed using Statistical Product for Social Sciences (SPSS) Ver. 20 through univariate analysis. The results were presented as a proportion of the frequency distribution.

Ethical consideration

This research has been declared ethically feasible by the Health Research Ethics Committee of the University of Muhammadiyah Malang (KEPK UMM) with Number E.5.a/121/KEPK-UMM/V/2020.

RESULTS

Out of a total of 151 respondents, almost half were aged between 25–35 years (50.3%), the proportion of respondents with junior high school education (39.1%) and high school (36.4%) showed an almost equal percentage. The proportion of respondents most came from the Bajo Tribe (31.8%) (Tab. 1).

Out of a total of 151 respondents, 76.2% of them did not know the best way to provide first aid for burns; almost all respondents (92.1%) did not know how long it would take to flush the burn area with water, and 77.4% of the 151 respondents did not know that a clean cloth could be used to cover the part affected by the burn (Tab. 2). In the question item about actions that can be taken within the first 15 minutes when providing first aid to

Table 1. Demographic characteristics of respondents (n = 151)

Demographic characteristics	n	[%]
Age		
< 25 years	76	13
25–35 years	19	50.3
36–45 years	28	19
> 45 years	26	17.2
Educational levels		
Elementary School	11	7.3
Junior High School	59	39.1
Senior High School	55	36.4
College	26	17.2
Ethnic group		
Bajo	48	31.8
Balantak	4	2.6
Banggai	20	13.2
Bugis	15	9.9
Buton	14	9.3
Gorontalo	14	9.3
Java	16	10.6
Makassar	1	0.7
Minahasa	8	5.3
Muna	2	1.3
Saluan	9	6.0

Table 3. Causes of burns (n = 151)

Causes of burns	n	[%]
Doused with hot water	76	30.5
Hit muffler	44	17.7
Exposed to hot oil	86	34.5
Got hit by fire	1	0.4
Exposed to electric iron	27	10.8
Exposed to hot pot	6	2.4
Electric shock	9	3.6

Table 4. Remedies for burn-related injuries

Remedies for burn-related injuries	n	[%]
Soy sauce	7	3.9
Oil	17	9.4
Toothpaste	107	59.4
Do nothing	3	1.7
Cold Water	43	23.9
Cold Egg White	1	0.6
Wound Ointment	1	0.6
Banana Slice	1	0.6

Table 2. Knowledge of first aid in burn-related injuries

Question	Correct answer	[%]	Wrong answer	[%]
What is the best way to treat burns?	36	23.8	115	76.2
How long does it take to flush the water on the burn wound?	12	7.9	139	92.1
Is it necessary to cover the affected part of the burn?	34	22.5	117	77.4
What did you do in the first 15 minutes of giving first aid to help a burn victim?	33	21.8	118	78.2
Will all burn injuries heal on their own using traditional remedies (home remedies)?	31	20.5	120	79.5

help victims who have burns, 78.2% of respondents answered incorrectly, and 79.5% of respondents thought that all burn injuries would heal on their own using traditional medicine (Tab. 2).

The causes of burns that often occur in the home environment are exposure to hot oil (34.5%) and scalding with hot water (30.5%) (Tab. 3).

Of a total of 151 respondents, more than half (59.4%) used toothpaste as first aid for burns and used plain cold water as the second choice (23.9%) (Tab. 4).

Of the 43 respondents (out of a total of 151) who used plain cold water as first aid for burns, more than half (48.8%) applied ordinary cold water to burns for 5–10 minutes (Tab. 5).

DISCUSSION

The perspectives of community and emergency care in layperson first aid for burn research are critical for improving results and lowering morbidity and

Table 5. Duration of application of cold water in first aid for burn-related injuries (n = 43 out of n = 151)

	n	[%]
Less than 5 Minutes	8	18.6
5–10 Minutes	21	48.8
More than 10 Minutes	14	32.6

mortality. According to studies, there is a need for improvement in the basic care of burn patients, particularly first aid management [18]. The primary focus in the early management of burn injuries is to ensure the survival of the individuals affected. This condition may occur due to the time it takes, which can range from hours to days, to transport patients to a facility where they can receive definitive care. By administering immediate first aid and early treatment, the severity of burn injuries can be significantly diminished, enhancing the likelihood of survival [17, 19, 20].

Based on this study, more than 75% of the respondents lacked awareness that cold water is the most efficient method of administering first aid for burns. In contrast to a survey conducted by Lam et al. among 674 at-risk workers, this finding contradicted the result that 86.1% of respondents had a good understanding of using cold water as first aid for burns. However, less than half of the respondents answered correctly about how long to apply the water [17]. In contrast to the survey conducted by Harvey et al., which reported that 82% of 7320 respondents used cold water as a first aid method for burns, the results of this study show a different outcome [21]. Caregivers are critical in providing fast and effective burn first aid, but their knowledge and practices are frequently insufficient. Many caregivers use non-scientific and ineffective home treatments for burns [22].

In this study, fewer than half of the respondents used a clean cloth to cover the burned areas on their bodies. This result aligns with Fadeyibi et al., who also found that covering wounds with a bandage or clean cloth effectively prevented infection [23]. In Lam et al.'s study, it was discovered that a majority of the respondents (64%) were unaware of the proper use of a clean cloth to cover burn-affected body parts [17]. Most respondents had completed junior high school and high school, contributing to their limited understanding of first aid for burns. In previous research by Wijaya et al., most respondents who had last education at the high school level with less knowledge of respondents [24]. Education is necessary to learn about factors contributing to improving one's quality of life and promoting good health [25].

Most respondents have an elementary education level, meaning that knowledge about first aid for burns is not taught explicitly in elementary schools [26]. Hence, there is a lack of understanding in this area. It cannot be assumed that as individuals age, their thinking process will become more mature when considering knowledge levels. Knowledge can also be influenced by external factors such as the surrounding environment and socio-cultural influences. According to Davies et al. [20], prior studies have indicated that individuals display conscientiousness in their actions, particularly when engaging in behaviors influenced by their parental upbringing. Another reason is that respondents frequently rely on information obtained through word of mouth, which may not be verified, thereby influencing the accuracy of the knowledge acquired by respondents.

First aid involves taking immediate action to assist the victim in preventing their condition from deteriorating before professional medical help arrives. The findings of this research demonstrate that common causes of burns in the home setting of Awu Village, Central Sulawesi Indonesia include contact with hot oil and scalding hot water [27]. Cox et al. [14] found that the causes of burns are often scalding with hot water and exposure to hot oil. Peck also mentioned that burns in the home environment account for 80% of cases, while burns in the workplace make up 20% [6]. According to Biswas et al., wound healing depends on the initial treatment provided to the victim. If the treatment is correct, it will reduce the severity of the wound or speed up the healing process. Conversely, if the treatment is not done correctly, it will harm wound healing [2]. The results showed that more than half of the respondents used toothpaste in first aid for burns. In the study of Wijaya et al., the results showed that 64.9% of respondents in the survey used toothpaste as a first aid for burns, which is consistent with the results of the current study [24].

The findings in this current study do not follow the guidelines issued by the ACI Statewide Burns Injury Service — Clinical Practice Guidelines, which states that burns are cooled with running water [28]. The respondents believed that utilizing cold water would exacerbate the burn injury. Both studies from Chirongoma et al. in Zimbabwe and Griffin et al. also found that water is applied to burns for

20 minutes; chemicals cause the burns, then continue cooling for 1–2 hours while paying attention to the victim's body temperature so that hypothermia does not occur [26, 29]. Furthermore, they believed that employing home remedies to alleviate pain and prevent infection would improve wound healing and a more favorable scar appearance. In this research, 25% of respondents utilized regular cold water as a first aid treatment for burns and administered it for 5–10 minutes.

Improving burn wound management is critical for wound care nurses in determining suitable treatments. Early burn therapy necessitates nursing-intensive care that focuses on delaying the burning process, preserving homeostasis, and replenishing lost fluids and electrolytes [30]. To achieve proper wound care therapy, the wound care team, which includes clinicians, charge nurses, and wound care technicians, must communicate and coordinate.

CONCLUSIONS

The study of first aid for burns has implications for both community and emergency areas. Education and training are critical to overcoming issues related to personal opinion and resource allocation, notably in the prevention of burn injuries and first aid. Consequently, it is crucial to implement an educational and training initiative to enhance awareness and skills in providing first aid for burn injuries in rural regions. Future research on first aid for burn injuries should concentrate on increasing knowledge and awareness among the community. Furthermore, research should seek to clarify and standardize burn wound cooling suggestions, such as the ideal temperature, manner, duration, and timing of therapy.

Article information and declarations

Data availability statement

The findings of this study are not openly accessible because of the need to protect respondent confidentiality. However, they can be obtained from the corresponding author upon a reasonable request.

Ethics statement

This research has been declared ethically feasible by the Health Research Ethics Committee of the University of Muhammadiyah Malang (KEPK UMM) with Number E.5.a/121/KEPK-UMM/V/2020.

Author contributions

Conceptualization: IDP. Data curation: IDP, RH. Formal analysis: IDP, RH. Methodology: IDP, RH, IW. Project administration: IDP, FFA. Visualization: IDP, RH. Writing – original draft: IDP, FFA. Writing – review & editing: IDP, RH, INW.

Funding

No financial support was provided to the author(s) for conducting the research, writing the article, or publishing it.

Acknowledgments

The authors would like to thank all the respondents in this research.

Conflict of interest

The authors declare no conflicts of interest.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 42–50
DOI: 10.5603/demj.97553

ISSN 2451–4691, e-ISSN 2543–5957

DOES OBESITY INFLUENCE THE RETURN OF SPONTANEOUS CIRCULATION AMONG OUT-OF-HOSPITAL CARDIAC ARREST PATIENTS? A RETROSPECTIVE COHORT STUDY

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ABSTRACT

INTRODUCTION: Several factors influence spontaneous circulation (ROSC) return in out-of-hospital cardiac arrest (OHCA) patients, and obesity can be one of them. The aim of this study was to investigate the influence of obesity on ROSC in patients following OHCA.

MATERIAL AND METHODS: We conducted a retrospective study and analyzed 4,925,214 emergency medical system (EMS) records. Finally, data from 33,636 OHCA patients in Poland for whom EMS personnel responded between January 2021 and June 2022 were analyzed.

RESULTS: The univariate analysis showed an association between ROSC and age ($p < 0.001$, OR: 0.981), location of the incident ($p < 0.001$, OR: 1.6), OHCA initial rhythm ($p < 0.001$, OR: 2.056), obesity ($p \approx 0.003$ OR: 1.1.06) and some comorbidities. In the first multivariate model (whole population sample), significant predictors of ROSC were initial rhythm (Asystole/PEA; $p < 0.001$; OR: 0.516), age ($p < 0.001$; OR: 0.986), location of the incident ($p < 0.001$; OR: 1.468) and obesity ($p = 0.023$; OR: 0.924). In the second model (patients without obesity), the significant predictors ($p < 0.001$) of ROSC were initial rhythm (Asystole/PEA, OR: 0.263), public location of the incident (OR: 2.158) and age (OR: 0.986). In the third model (patients with obesity), the significant predictors of ROSC were initial rhythm (Asystole/PEA, $p = 0.002$; OR: 0.443), public location of the incident ($p < 0.001$; OR: 2.101), age ($p < 0.001$; OR: 0.981), and stroke ($p = 0.005$; OR: 2.047).

CONCLUSIONS: In the study population of OHCA patients, obesity significantly predicted the odds of the prehospital return of spontaneous circulation, reducing the odds by 8.2%. In the overall study population and the groups of patients with and without obesity, OHCA in public places and ventricular fibrillation/pulsless ventricular tachycardia (VF/pVT) initiating rhythm were predictors of increased odds of ROSC and older age reduced these odds.

KEYWORDS: out-of-hospital cardiac arrest; return of spontaneous circulation; obesity; cardiopulmonary resuscitation

Disaster Emerg Med J 2024; 9(1): 42–50

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Received: 22.09.2023 Accepted: 18.10.2023 Early publication date: 6.12.2023

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a sudden and unexpected event associated with a high mortality risk and serious neurological complications [1]. Following advanced life support (ALS), the return of spontaneous circulation (ROSC) at the scene was reported to occur in 10 to 50% of OHCA patients [2]. Over the past few decades, significant advances in ALS have improved survival rates after OHCA [3]. Nevertheless, numerous factors can still influence the outcome of emergency medical teams' rescue efforts and, among these, ROSC.

Obesity, as a global health problem, has increased significantly over recent years. Its prevalence in adult and child populations is increasing alarmingly, with serious public health implications [4]. According to the World Health Organization (WHO), up to 13% of the world's population struggles with obesity [5] Several studies have shown that obesity affects both the risk of CVD (such as hypertension, coronary heart disease, and heart failure) and increased complications in people with these conditions [6–9]. On the other hand, some studies have shown that obesity does not affect the outcome of patients following CA [10].

It is worth pointing out that this condition is essential not only because of the presence of comorbidities in patients but also due to the difficulty in meeting ERC guidelines. An example is maintaining the correct depth of chest compressions due to differences in anatomy [11, 12]. In such a case, it is also challenging for the emergency teams to perform endotracheal intubation or insert an intravenous or intraosseous line [13]. According to the current ERC guidelines, ALS procedures in patients with obesity are not different from the treatment of an adult patient of normal weight, and they do not give specific recommendations in this regard [11].

The aim of this study was to investigate the influence of obesity on ROSC in patients following OHCA.

MATERIAL AND METHODS

Study design and setting

We performed a retrospective analysis of the medical records of patients for whom emergency medical services (EMS) were called in Poland from January 2021 till June 2022. The data were obtained from the Command Support System of the National Emergency Medical Service and made available by the Emergency Medical Services Monitoring Centre with the permission of the Polish Ministry of Health.

Study population

A total of 4,925,214 EMS records were analyzed. All patients with a recorded ICD 10 — I 46 diagnosis who received cardiopulmonary resuscitation (CPR) at the scene were included in the study. Patients in whom OHCA occurred due to crime, suicide, trauma, etc., in whom death occurred prior to EMS arrival, and in whom the rhythm initiating OHCA was not recorded were excluded from the study. Finally, data from 33,636 patients were analyzed. In the next step, information on the presence of obesity (ICD10: E66 or the word diagnosis "obesity") was exported from both the ICD10 section and the "descriptive diagnosis" section of the medical records to divide the patients into two groups: patients without obesity and patients with obesity (Fig. 1). The following data were then analyzed: age, sex, initiating rhythm, location of OHCA (public place, non-public place), information on the presence of comorbidities such as diabetes mellitus (DM), hypertension (HT), heart failure (HF) and history of acute coronary syndrome (ACS) and stroke.

Ethical considerations

The study was conducted following the principles of the Declaration of Helsinki and was approved by the independent Bioethics Committee of Wrocław Medical University (No. KB-776/2022). The study followed the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).

Statistical analysis

Data extraction and preprocessing were performed in Python 3.10.7 using standard packages (pandas 1.4.4, numpy 1.21.4). Statistical analysis was performed in STATISTICA 5.0.96. The data were visualized using the following Python packages: matplotlib 3.5.3 and zepid 0.9.1.

Analysis of continuous variables was performed with the t test based on its assumptions (normality: as analyzed on a histogram, homoscedasticity: based on Levene's test). Analysis of categorical variables was performed with the χ^2 test. Odds ratios (ORs) associated with variables in contingency tables were calculated using univariate logistic regression. Further analysis was performed with the use of multiple logistic regression — utilizing the stepwise

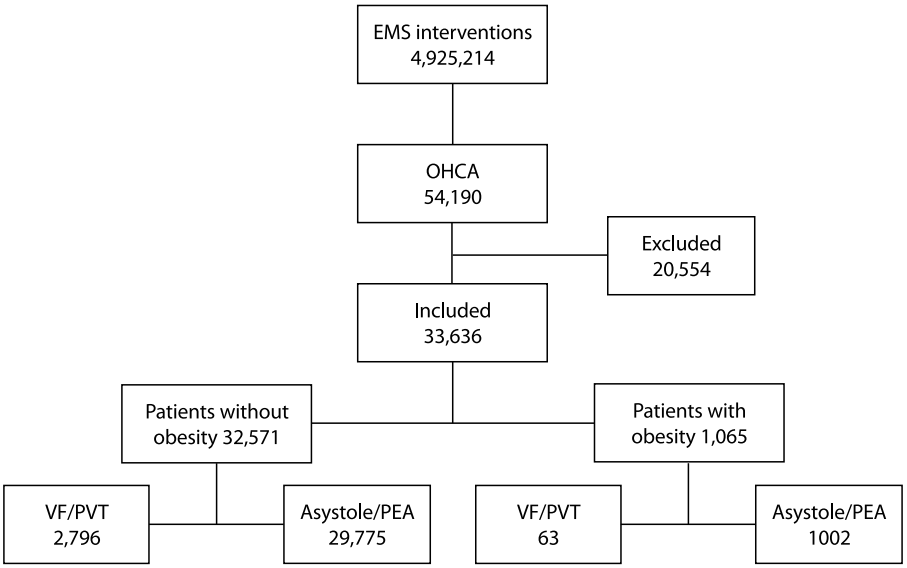

FIGURE 1. Flow chart of the study; OHCA — out-of-hospital-cardiac-arrest; PEA — pulseless electrical activity; pVT — pulseless ventricular tachycardia; VF — ventricular fibrillation

regression algorithm (p cut-off: 0.05) based on Wald and Lagrange multiplier (score) tests.

RESULTS

Factors of ROSC in the whole dataset

The univariate analysis (Tab. 1) showed an association between ROSC and age ($p < 0.001$), location of the incident ($p < 0.001$), OHCA initial rhythm ($p < 0.001$), obesity ($p \approx 0.003$), DM ($p \approx 0.028$), HT ($p \approx 0.015$) and ACS ($p < 0.001$). With a one-year increase, the odds of ROSC incidence dropped by approximately 1.94%. If the incident occurred in a public place, the odds of ROSC were 1.60--fold higher compared to the domicile location. Over 2-fold (2.056) higher odds of ROSC were observed in individuals with the ventricular fibrillation/pulsless ventricular tachycardia (VF/pVT) initial rhythm, compared to the Asystole/PEA. Obesity and diabetes decreased ROSC odds by approximately 10.6% and 3.5%, respectively. HT decreased these odds by approximately 3.4%, while acute coronary syndrome increased the odds by 15.1%. Neither sex nor stroke or HF affected the odds of ROSC (p: 0.079, 0.721, 0.367, respectively).

The derived multivariate model (Tab. 3A) utilized the information on initial rhythm ($p < 0.001$), age ($p < 0.001$), OHCA location ($p < 0.001$) and obesity ($p \approx 0.023$). The VF/pVT OHCA initial rhythm showed approximately 1.92-fold lower ROSC odds than the VF/pVT initial rhythm. A one-year increase in age decreased these odds by approximately 1.01%. Obesity decreased the odds by approximately 8.70%.

Factors of ROSC depending on obesity status

After splitting the population sample based on obesity status (Tab. 2), both strata showed an association between the odds of ROSC and age ($p < 0.001$), OHCA location ($p < 0.001$), and initial rhythm ($p < 0.001$). A one-year increase in age decreased the odds by approximately 1.94% in patients without obesity and 2.35% in patients with obesity. If the incident occurred in a public place, the odds for ROSC increased by approximately 60.1% and 55.8% (compared to the domicile location) in nonobese and obese individuals, respectively. Likewise, as shown in the whole dataset, the VF/pVT initial rhythm was associated with higher odds of ROSC compared to the Asystole/PEA in nonobese (2.065-fold higher odds) and obese (1.652-fold higher odds) individuals. The difference between the nonobese and obese strata lay in the association between the odds of ROSC and stroke (45.1% increase in the odds in the obese, no association in the nonobese), HT (no association in the obese, 3.1% decrease in the odds in the nonobese) and acute coronary syndrome (no association in the obese, 15.3% increase in the odds among the nonobese). Results of univariate logistic regression measuring the odds of ROSC after stratification by obesity status (only the significant ORs) are shown in Figure 2.

Table 1. The univariate association between selected factors and the odds of return of spontaneous circulation (ROSC) in the whole population sample

Variable	Desc. Stat.	ROSC: No	ROSC: Yes	p value	OR	OR — 95%	OR 95%
Age	n	21431	11924	< 0.001	0.981	0.980	0.983
	Mean ± SD	69.37 ± 15.08	65.01 ± 17.07				
Sex: male	n (column %)	13818 (63.98)	7818 (64.94)	0.079	1.021	0.998	1.045
Location — a public place: Yes	n (column %)	2914 (13.49)	3435 (28.53)	< 0.001	1.600	1.556	1.645
Initial rhythm: VF/pVT	n (column %)	932 (4.32)	1927 (16.01)	< 0.001	2.056	1.973	2.141
Obesity: Yes	n (column %)	730 (3.38)	335 (2.78)	0.003	0.905	0.847	0.966
Diabetes: Yes	n (column %)	3504 (16.22)	1843 (15.31)	0.028	0.966	0.937	0.996
Stroke: Yes	n (column %)	1157 (5.36)	656 (5.45)	0.721	1.009	0.961	1.060
Hypertension: Yes	n (column %)	4879 (22.59)	2582 (21.45)	0.015	0.967	0.941	0.994
Heart failure: Yes	n (column %)	1801 (8.34)	970 (8.06)	0.367	0.981	0.942	1.022
Acute Coronary Syndrome: Yes	n (column %)	776 (3.59)	566 (4.70)	< 0.001	1.151	1.089	1.216

CI — confidence interval; n — number of patients; OR — odds ratio; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

The multivariate models (Tab. 3B, 3C) utilized the information on age, OHCA initial rhythm and location, regardless of obesity status. Additionally, the model analyzed for obese individuals used the information on stroke incidence ($p \approx 0.005$). The adjusted ORs in the nonobese or obese strata were 0.263 or 0.443 (Asystole/PEA vs VF/pVT), 0.986 or 0.981 (upon increase in age by one year), and 2.158 or 2.101 (a public place vs at home), respectively. Obese individuals who suffered from stroke were of approximately 2.047-fold higher odds of ROSC. Results of multivariate logistic regression models measuring the odds of ROSC (only the significant ORs) are shown in Figure 3.

DISCUSSION

Out-of-hospital cardiac arrest remains the most critical condition in EMS practice, and the prognosis of a patient with this condition remains poor. With the growing problem of obesity worldwide, paramedics are encountering an increasing number of patients with obesity in the line of duty [14]. The main aim of this study was to assess the impact of obesity on ROSC in patients with OHCA. Obesity was a significant predictor of ROSC in univariate and multivariate models. In multivariate analysis among the entire population sample, the odds of ROSC increased when OHCA occurred in a public place and decreased when the initiating rhythm was asystole/PEA and with increasing patient age. This phenomenon was observed in all patients and when patients were divided into groups of those with and without obesity. These findings are well-known and are supported by the results of previous studies [15–19]. In a multivariate analysis in the group that included all patients, obesity was a significant predictor and reduced the odds of ROSC by 8.2%. Since obesity is associated with many diseases, such as CVD, this finding may be not surprising [20]. The results on the impact of obesity on ROSC are inconsistent. Some studies show that patients with obesity were relatively younger and more likely to present with shockable initial rhythms, which could be explained by a higher incidence of prehospital ROSC [21–23]. Performing high-quality CPR on patients with obesity can be difficult for several reasons, including the increased anterior-posterior dimension of the chest [24]. Secobame et al. pointed out that the presence and distribution of adipose tissue around the chest (quantified by computed tomography at an average of 36.53 mm anteriorly and 50.73 mm posteriorly) in this group of patients may reduce compression efficacy [25]. Obesity can also cause difficulties in managing airway patency and restoring a normal heart rhythm in inpatients requiring defibrillation [26, 27]. The authors of some studies have found that obesity (measured by body mass index) after OHCA is associated with better outcomes in sudden cardiac arrest (SCA) survivors. They refer to this as

Table 2. The univariate association between selected factors and the odds of return of spontaneous circulation (ROSC) in the context of variable obesity status

Variable	Desc. Stat.	Obesity: No						Obesity: Yes					
		ROSC: No	ROSC: Yes	p value	OR	OR — 95%	OR 95%	ROSC: No	ROSC: Yes	p value	OR	OR −95%	OR 95%
Age	n	20709	11592	< 0.001	0.981	0.980	0.983	722	332	< 0.001	0.977	0.969	0.985
	Mean±SD	69.36 ± 15.10	64.96 ± 15.18					69.61 ± 14.60	64.10 ± 16.32				
	Missing data	158	112					8	3				
Sex: male	n [column %]	13384 [64.14]	7612 [65.04]	0.104	1.020	0.996	1.044	434 [59.45]	206 [61.49]	0.528	1.044	0.914	1.192
Location — a public place: Yes	n [column %]	2818 [13.51]	3345 [28.58]	< 0.001	1.601	1.556	1.647	96 [13.15]	90 [26.87]	< 0.001	1.558	1.325	1.831
Initial rhythm: VF/pVT	n [column %]	903 [4.33]	1893 [16.17]	< 0.001	2.065	1.982	2.153	29 [3.97]	34 [10.15]	< 0.001	1.652	1.278	2.136
Diabetes: Yes	n [column %]	3181 [15.24]	1701 [14.53]	0.085	0.972	0.942	1.004	323 [44.25]	142 [42.39]	0.570	0.963	0.845	1.097
Stroke: Yes	n [column %]	1121 [5.37]	623 [5.32]	0.850	0.995	0.946	1.047	36 [4.93]	33 [9.85]	0.002	1.451	1.135	1.856
Hypertension: Yes	n [column %]	4509 [21.61]	2410 [20.59]	0.031	0.970	0.943	0.997	370 [50.68]	172 [51.34]	0.841	1.013	0.890	1.153
Heart failure: Yes	n [column %]	1651 [7.91]	895 [7.65]	0.392	0.982	0.941	1.024	150 [20.55]	75 [22.39]	0.494	1.056	0.903	1.235
Acute Coronary Syndrome: Yes	n [column %]	738 [3.54]	544 [4.65]	< 0.001	1.153	1.090	1.220	38 [5.21]	22 [6.57]	0.371	1.131	0.863	1.483

CI — confidence interval; n — number of patients; OR — odds ratio; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

Table 3. The multivariate association between selected factors and the odds of return of spontaneous circulation (ROSC): in the whole population sample (A), among the nonobese (B) and obese (C) only

(A) Whole population sample; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.049	0.065	264.29	< 0.001	2.854	2.515	3.239
Initial rhythm	VF/pVT	Asystole/ PEA	−0.662	0.021	960.87	< 0.001	0.516	0.494	0.538
Location: a public place	No	Yes	0.384	0.015	668.27	< 0.001	1.468	1.426	1.512
Age	–	–	−0.014	0.001	313.28	< 0.001	0.986	0.985	0.988
Obesity	No	Yes	−0.079	0.035	5.18	0.023	0.924	0.863	0.989
(B) Nonobese individuals; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.406	0.068	423.66	< 0.001	4.078	3.567	4.663
Initial rhythm	VF/pVT	Asystole/ PEA	−1.337	0.043	953.12	< 0.001	0.263	0.241	0.286
Location: a public place	No	Yes	0.769	0.030	649.43	< 0.001	2.158	2.034	2.290
Age	–	–	−0.014	0.001	295.91	< 0.001	0.986	0.985	0.988
(C) Obese individuals; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.086	0.397	7.49	< 0.001	2.962	1.361	6.445
Location: a public place	No	Yes	0.743	0.171	18.92	< 0.001	2.101	1.504	2.936
Age	–	–	−0.019	0.004	18.590	< 0.001	0.981	0.972	0.989
Initial rhythm	VF/pVT	Asystole/ /PEA	−0.815	0.272	8.98	0.002	0.443	0.260	0.754
Stroke	No	Yes	0.716	0.258	7.71	0.005	2.047	1.235	3.395

CI — confidence interval; OR — odds ratio; PEA — pulseless electrical activity; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

the "obesity paradox" [28, 29]. This phenomenon has also been repeatedly described in life-threatening conditions that can lead to SCA, such as ACS or HF [30]. The authors explain that this phenomenon may be influenced by age — patients with obesity are often younger (in our analysis, the people with obesity in whom ROSC was obtained were also younger) [31]. Additionally, previous diagnosis and treatment, for example, of CVD (obese people are more likely to undergo preventive screening), could also play a role in this phenomenon [20]. In patients admitted to intensive care, adipose tissue can serve as a nutrient when metabolism increases rapidly [32]. However, the claim is most commonly used when BMI is used to assess obesity, which has many limitations, such as not differentiating between obesity phenotypes and not taking into account body composition (amount of body fat, muscle tissue) or edemaedema in patients with HF [33]. Sharma et al. [34] rightly pointed out that in most cases, a more appropriate name for this phenomenon is the 'BMI paradox'. Recent studies, both in patients after OHCA and in other life-threatening conditions, suggest that the 'obesity paradox' does not exist and that the protective effect of obesity should not be considered [35, 36]. Taking into account all the possible consequences of obesity (both problems with life support and health complications), the ERC guidelines rightly emphasize the need for CA prevention, including early detection and treatment

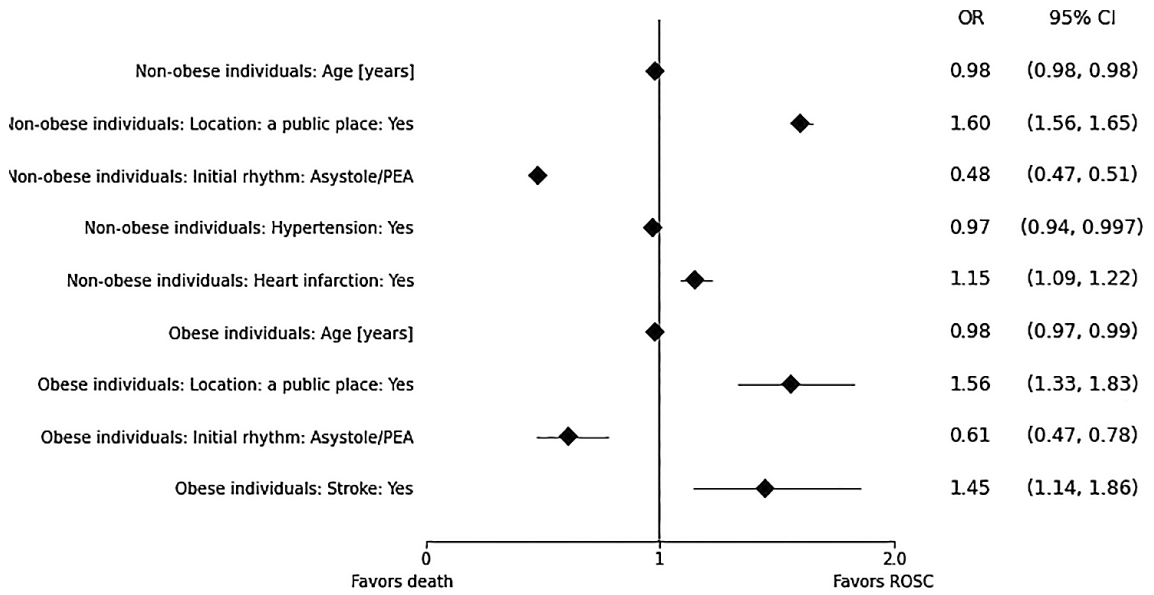

FIGURE 2. Univariate odds ratios (ORs) associated with return of spontaneous circulation (ROSC); CI — confidence interval

of, for example, coronary heart disease, with which obesity is strongly correlated [1, 37]. In multivariate analysis among patients with obesity, there was a higher chance of ROSC among individuals who suffered from stroke. There are reports in which patients with OHCA in the etiology of stroke had a higher chance of ROSC but a lower chance of favorable neurological outcome and even 30-day survival in relation to cardiac etiology [38]. However, due to limited data from the medical records of the OHCA cases studied, this result should be interpreted highly cautiously and requires further prospective studies in this area.

Study limitation

The limitations of this study are related to its retrospective nature and the database characteristics used. First, data on comorbidities, for example, are uncertain because in many cases, the ambulance service may not have had contact with the family witnesses to the incident or access to the patient's medical history. For example, it is not possible to determine from the medical records examined whether the stroke occurred immediately before the OHCA or whether it was in the past. No specific field in the emergency medical record indicates whether witnesses to the incident started CPR before the team arrived or how long CPR lasted, so it was impossible to include this parameter in the analysis. The medical records were anonymous, so looking at long-term survival was impossible. A strength of the study was undoubtedly the large sample size, which included the entire Polish population.

CONCLUSIONS

In the study population of out-of-hospital cardiac arrest patients, obesity significantly predicted the odds of the prehospital return of spontaneous circulation, reducing the odds by 8.2%. In the overall study population and the groups of patients with and without obesity, cardiac arrest in public places and VF/pVT initiating rhythm were predictors of increased odds of return of spontaneous circulation and older age reduced these odds. Studies on the obesity status of OHCA patients need to be further investigated.

Article information and declarations

Data availability statement

The selected range of data and materials is available after direct contact with the correspondence author.

Ethics statement

The study was conducted following the principles of the Declaration of Helsinki and was approved by the independent Bioethics Committee of Wrocław Medical University (No. KB-776/2022). The study followed the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).

Author contributions

Conceptualization, P.F. and M.C.; methodology, P.F., Ł.L. and M.C.; software, P.F.; validation, P.F.; formal analysis, P.F., Ł.L. and M.C.; investigation, P.F.; resources, P.F. and J.S.; data curation, P.F. and J.S.; writing — original draft preparation, P.F., Ł.L., M.C., I.U. and J.S.; writing — review and editing, P.F., J.S. and M.C.; visualization, P.F. and Ł.L.; supervision, M.C.; project administration, P.F. and M.C.; funding acquisition J.S and M.C. All authors have read and agreed to the published version of the manuscript.

Funding

This research was funded by the Ministry of Science and Higher Education of Poland under the statutory grant of the Wrocław Medical University (SUBZ. E240.23.021).

Acknowledgments

Not applicable.

Conflict of interest

None of the authors has declared a conflict of interest.

Supplementary material

None.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 51–57
DOI: 10.5603/demj.97341

ISSN 2451–4691, e-ISSN 2543–5957

EVALUATION OF VENTILATION QUALITY CONDUCTED BY FIREFIGHTERS DURING SIMULATED CARDIOPULMONARY RESUSCITATION

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ABSTRACT

INTRODUCTION: High-quality ventilation in unconscious victims is a priority action for first responders at the scene. Firefighters often arrive first at the scene, providing medical assistance at the level of qualified first aid (QFA). This research aimed to evaluate the quality of ventilation using supraglottic methods with and without visual feedback and self-inflating bags during simulated cardiopulmonary resuscitation (CPR) performed by members of the State Fire Service (SFS).

MATERIAL AND METHODS: A cross-sectional study was conducted in organizational units of the State Fire Service (SFS) in the Lubelskie and Warmińsko-Mazurskie voivodeships (24-hour duty officers). 112 firefighters aged 26–48 years (Mean 33.1; SD 6.7), with service duration of 1-20 years (Mean 7.3; SD 4.7) participated in the study. The study involved a 2-minute supraglottic ventilation (self-expanding bag + I-gel mask, size 4: 50–90 kg). Subsequently, 2-minute ventilation was conducted with the effectiveness visible on the monitor in real-time. The following ventilation variables were recorded: frequency (per minute), the volume of each inhalation (mL), and the ratio of correct to incorrect single inhalations (%).

RESULTS: It was shown that in stage 1, firefighters more often ($P < 0.001$) performed ventilation at an excessively high frequency (max rate = 14 ± 4) compared to stage 2 (max rate = 11 ± 1). A statistically significant influence of the possibility of assessment and correction of rescue actions in real-time on the correct frequency (% correct – rate = 52.3 ± 30.1 vs 91.4 ± 12.1; $P < 0.001$) and ventilation volume (% correct — V = 40.6 ± 28.2 vs 85.3 ± 15.0; $P < 0.001$) was demonstrated. No statistically significant impact of service duration and age on evaluating parameters in stages 1 and 2 was shown.

CONCLUSIONS: Software assistance and the possibility of real-time feedback significantly improve the quality of ventilation conducted by firefighters using supraglottic airway device (SAD). More training using elements of medical simulation with visual feedback should be introduced so that firefighters improve ventilation quality under realistic conditions. Consideration should be given to including tools for assessing CPR quality in CPR rescue kits, especially in units that, according to statistics, handle a larger number of EMS interventions.

KEYWORDS: airway patency; emergency medical rescue; ventilation; SAD; firefighting and rescue operations

Disaster Emerg Med J 2024; 9(1): 51–57

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Received: 08.09.2023 Accepted: 22.11.2023 Early publication date: 19.12.2023

INTRODUCTION

High-quality ventilation in unconscious victims is a priority action for first responders at the scene. Firefighters often arrive first at the scene, providing medical assistance at the level of qualified first aid (QFA). These entities rely on rescue procedures to assist both trauma and non-trauma victims. For QFA procedures, firefighters utilize rescue kits described in the "Principles of medical rescue organization in the National Fire and Rescue System" [1].

Medical kits for firefighters allow for cardiopulmonary resuscitation (CPR) and maintaining open airways in unconscious victims using supraglottic methods (SAD, supraglottic airway device) [2]. This ensures a higher quality of ventilation for the victim while waiting for the State Medical Rescue (SMR) units, which are equipped with superior equipment as the leading service in medical rescue and stocked with resuscitation drugs. Firefighters cooperate with SMR without having statutorily equipped drugs [3].

Interventions where firefighters conduct medical operations independently before the SMR arrives are classified as isolated medical rescue events (IMRE). This includes situations when dispatching a SMR ambulance is not feasible, or when the expected ambulance arrival time is considerably longer than the time of arrival for a Fire Protection Unit (FPU). The deployment of firefighters then occurs upon request of a medical dispatcher (MD) via a command post (CP), which is equivalent to MD in the SMR system. IMRE criteria also encompass firefighter interventions when, upon returning from their operations or exercises, they notice or witness situations requiring QFA procedures implementation [4].

Properly securing the airway patency of a victim in sudden cardiac arrest (SCA) is a priority action in pre-hospital rescue due to the short time reserves of progressing hypoxia [5]. SAD methods offer an effective alternative to airway clearance and ventilation to intubation, which is considered the "gold standard" and provides the highest level of airway security [6]. Firefighters do not perform intubation procedures due to the limited number of firefighters with medical training, resulting in a lack of systematic training and the absence of this method in equipment sets.

The number of medics in the State Fire Service (SFS) is about 2,200 firefighters [7], accounting for approximately 7% of the 32,000-strong population of professional firefighters [8].

This research aimed to assess the quality of ventilation using supraglottic methods with and without visual feedback and self-inflating bags during simulated cardiopulmonary resuscitation carried out by SFS officers.

MATERIAL AND METHODS

Research design

A cross-sectional study was conducted in organizational units of the SFS in the Lubelskie and Warmińsko-Mazurskie provinces (Poland) among officers serving in combat divisions. The study population consisted of 112 firefighters aged 26–48 (Mean 33.1; SD 6.7), with a service length of 1–20 years (Mean 7.3; SD 4.7) who take direct part in firefighting and rescue operations. The largest group consisted of firefighters with 1–5 years of service (n = 42). Daily service officers (*i.e.*, 8-hour shifts) and civilian employees were excluded from the group. The study was conducted from 1.12.2022 to 25.04.2023.

Research setting

The study was dedicated to firefighters who do not simultaneously practice medicine and who do not have daily experience with rescue kits, including supraglottic methods for airway clearance and ventilation with a self-inflating bag.

Study procedure

The research was conducted using a training station (adult mannequin Rescue Anne QCPR Airway Head + cardiomonitor Zoll X Series Advanced with a ventilation quality measurement sensor Accu Vent). Each officer underwent preliminary instruction to fully understand the study scenario. Each firefighter participating in the study had to conduct victim ventilation (simulation-mannequin) in two stages (each lasting 2 minutes). For research and statistical calculations, the study time was expressed in seconds:

- stage 1: T1 measured in seconds (T1 max = 120 seconds), parameter abbreviations used in tables and figures in the Results chapter: volume V1, frequency R1;
- stage 2: T2 measured in seconds (T2 max = 120 seconds), parameter abbreviations used in tables and figures in the Results chapter: volume V2, frequency R2.

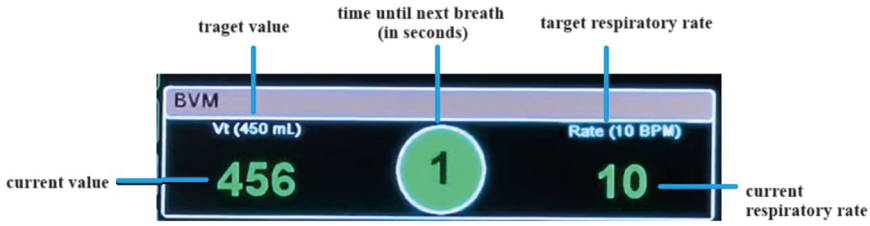

FIGURE 1. Visualization of the feedback in real time — stage 2 (visible on the cardiomonitor screen)

In both stages, the effectiveness of the conducted ventilation was assessed using two parameters determining ventilation quality:

— ventilation volume;
— ventilation frequency asynchronously to chest compressions, taking into account supraglottic methods.

Additionally, the software (Real Bag Valve Mask (BMV) Help in Zoll X Series Advanced) allowed the calculation of the ratio of correct breaths to all performed during the two-minute stage. The study assumed asynchronous CPR ventilation for an adult weighing around 65 kg. The correct values based on guidelines calculated 6–8 mL per kilogram of body weight [9]:

— volume: standard 500 mL (tolerance: –10%; +10%) — breaths within 450–550 mL were recognised as correct by the algorithm;
— frequency: standard 10/min (tolerance: –10%; +10%) — frequency 9–11/min. was recognised as correct by the algorithm.

Differences between stage I and II:

— stage 1: ventilation without the possibility of real-time rescue operation assessment;
— stage 2: ventilation with real-time assessment and correction capability, thanks to the use of a monitor/defibrillator equipped with a ventilation measurement module for BVM. Measurements cover two values showing the correctness of the conducted ventilation: the volume administered to the patient and the frequency of administered substitute/supplementary breaths. Data recording and storage were ensured by a flow sensor located at the exit of the breathing mixture from the self-inflating bag before the patient's mouth, regardless of the method of ventilation (face mask, laryngeal tube, laryngeal mask, tracheal tube).

Each participant in the study went through stage 1, then stage 2, in which the defibrillator was turned with its screen facing the subject so that they could correct its operation in real-time (real-time visual feedback described in Fig. 1). The results and quality after stage 1 obtained were not discussed to avoid a false positive effect in terms of improving quality in stage 2.

Chest compressions were not considered in the study, and they were not performed. The anticipated break between stages 1 and 2 was 2 minutes, related to saving activity in the cardiometer memory activating the data collection module and connecting the sensor to the ventilation set. The study was conducted in normothermia (room temperature) and standard air humidity conditions. These conditions were achieved in a heated medical training room at the Training Center of the SFS Provincial Headquarters.

Ethical considerations

The study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Ethics Committee No. 16/2022 ABNS. Firefighters participating in the study remained anonymous. The study was voluntary, and participants were informed about this. In September 2022, permission was obtained from the Voivodeship Commander of the SFS in Lublin and Olsztyn to conduct the study in the regions.

Intervention records

For the purpose of the study, a database was created in which the following sociodemographic data of the participants were collected: age, gender, and length of service. The results were interpreted based on an automatically created database of each activity at the workstation. The pattern for interpreting the results is shown in Table 1.

Statistical analysis

Results concerning quantitative variables were presented as average values ± standard deviation. Qualitative variables were presented as quantity (n)

Table 1. Method of result interpretation — data presented by the software, an example of 1 minute of study implementation for a randomly selected firefighter

Activity time**	Interval in seconds	Calculated frequency	Rating	Calculated volume	Rating
xx.xx.2023 11:47:**59**	6	10	T	429	F
xx.xx.2023 11:48:**05**	6	10	T	470	T
xx.xx.2023 11:48:**11**	5	11	T	458	T
xx.xx.2023 11:48:**16**	5	11	T	480	T
xx.xx.2023 11:48:**21**	5	12	F	407	F
xx.xx.2023 11:48:**25**	4	13	F	468	T
xx.xx.2023 11:48:**31**	6	10	T	475	T

F —false: a single breath counted as incorrect; T — true: single breath counted as correct; xx — full date not given, protection of group personal data. On the basis of the ratio of ventilation marked T to all attempts in the 2-minute stage, the percentage of correct breaths was calculated

**Seconds are described in a bold font to draw attention to the essence of the record. The exact time of subsequent activities was automatically converted into frequency by the software. The algorithm of the program took into account the frequency of the commenced activity and the time of execution of each ventilation, therefore, comparing the same interval values (seconds), it calculated a different minute frequency

and percentage values of the whole group (%). The normality of the distributions was tested with the Kolmogorov-Smirnov test. As the parametric tests did not meet the criteria, nonparametric tests were used in the study. A Wilcoxon matched-pairs test (non-parametric test) was used in the comparative characteristics (stage 1 vs stage 2). In the comparative analysis of length of service and age and ventilation efficiency, Spearman's rho correlation coefficient was applied to detect and describe the strength and direction of correlations. Statistica 13 software (StatSoft Inc., Tulsa, OK) was used in the statistical analysis. $P < 0.05$ was adopted as the significance level.

RESULTS

112 firefighters aged 26–48 (Mean 33.1; SD 6.7), with a service length of 1–20 years (Mean 7.3; SD 4.7) participated in the study. The largest group consisted of firefighters with 1–5 years of service ($n = 42$). Statistically significant differences were demonstrated between the effectiveness of the ventilation performed in stage 1 and stage 2. It was shown that in stage 1, firefighters statistically more often ($p < 0.001$) ventilated with too high frequency (max rate = 14 ± 4) compared to stage 2 (max rate = 11 ± 1). The analysis of the correct frequency showed a statistically significant effect of real-time assessment and correction on the correct frequency (% correct — rate = 52.3 ± 30.1 vs 91.4 ± 12.1; $P < 0.001$) and volume of ventilation (% correct — V = 40.6 ± 28.2 vs 85.3 ± 15.0; $p < 0.001$) — Table 2.

In the analysis, no statistically significant impact of subjects' service length and age on assessing the parameters of ventilation effectiveness was demonstrated, both in stages 1 and 2.

DISCUSSION

The presented study with an element of medical simulation allowed us to evaluate how modern medical equipment and new technologies can influence the quality of rescue operations, in this case, Basic Life Support (BLS) executed by firefighters. A cardiac monitor with ventilation or chest compression assessment (assistant) is not commonly used among firefighters. Participation in the study was also a good opportunity for the officers to recall more challenging BLS procedures, which are rarely used in their practice.

A crucial aspect of firefighter skills is the training system, obtaining certifications, and maintaining BLS qualifications. BLS recertification is conducted every three years for every firefighter, excluding those with a medical background, who undergo professional medical improvement in accordance with the SMR Act. The present study did not consider whether the officer has a medical education in the achieved quality of ventilation [10].

Several factors influence the quality of pre-hospital ventilation: maintaining open airways, selecting the appropriate method and size of the device, atmospheric conditions, and the skills and experience of the rescuer. This study evaluated the baseline skills of a rescuer vs the skills of an assistant in the cardiac monitor. Several other studies describe supraglottic

Table 2. Univariate comparison of ventilation frequency and volume

Parameter	Stage 1	Stage 2	Z-value	Effect size-r_C	P
Rate	11 ± 3	10 ± 1	4.217	0.404	< 0.001
Min rate	8 ± 3	9 ± 1	3.532	0.368	< 0.001
Max rate	14 ± 4	11 ± 1	7.535	0.781	< 0.001
% correct — rate	52.3 ± 30.1	91.4 ± 12.1	8.741	0.861	< 0.001
Volume	520.6 ± 85.4	520.9 ± 31.0	0.294	0.028	0.769
Min V	412.7 ± 115.2	462.8 ± 47.2	4.371	0.415	< 0.001
Max V	626.2 ± 118.3	570.5 ± 37.0	4.919	0.471	< 0.001
% correct V	40.6 ± 28.2	85.3 ± 15.0	8.572	0.814	< 0.001

Max — maximum; Min — minimum; V — volume; P — probability value; Effect size- r_C — calculating effect sizes: Cohen's d (also known as the standardized mean difference); Z-value — a test statistic for Z-tests that measures the difference between an observed statistic and its hypothesized population parameter in units of the standard deviation

methods as alternatives to tracheal intubation, *e.g.*, Soar et al. [11] in the European Resuscitation Council (ERC) guidelines review describes the sequence of advanced activities (ALS) during CPR: defibrillation, airway clearance, oxygenation and ventilation, circulatory support, monitoring, drugs.

Länkimäki et al. [12] define activities related to ventilation as airway management to ensure sufficient gas exchange which is of paramount importance. This includes intubation and SAD methods, including laryngeal mask airways (LMA). The described techniques fit the criteria of the present study, *i.e.*, using SAD when intubation is not possible in firefighters' practice.

Enterlein et al. [13] emphasize the time of effective airway clearance and maintaining their patency, as well as the role played by the knowledge and experience of rescuers. Effectively clearing the airways requires knowledge of respiratory anatomy, equipment familiarity, and manual dexterity from rescuers, and achieving open airways should take up to 30 seconds. The present study did not consider such criteria, although it is essential to assess airway clearance by firefighters in relation to time criteria in the future.

Improper ventilation is associated with impaired haemodynamics and leads to increased morbidity and ultimately, mortality. Hyperventilation results in decreased PaCO2, leading to the constriction of central nervous system vessels and reduced brain blood flow, which causes brain tissue damage. Research results from O'Neill et al. show that hyperventilation is mainly the consequence of excessive ventilation frequency rather than excessive volume [14].

To understand factors that might affect the efficacy of manual ventilation, one should fully investigate operator characteristics, including hand size and grip strength. Studies by Sall et al. indicate that the size of the hand gripping the bag is particularly important, especially for novice medical staff, firefighters, and first aid volunteers. Individuals with larger hands tend to hyperventilate, while those with smaller hands tend to hyperventilate more often. This factor was not considered in the aforementioned studies, but it is worth noting in the future [15].

American firefighters also possess medical equipment and victim care procedures. Bolland et al. [16] describe firefighters' independent interventions before medical teams arrive and the use of procedures, including the use of SAD (325 cases of cardiac arrest), ventilation, defibrillation, and resuscitative pharmacotherapy. Polish firefighters' medical rescue kits are not equipped with pharmacology, yet they complement the SMR system, implementing ALS-level procedures while waiting for medical teams, which can improve prognosis in many cases.

Tymiński points out the competency gap of BLS rescuers that could enhance the quality of firefighters' medical interventions, indicating, for instance, the inability to monitor victims, and access intravenous therapy, intravenous, intramuscular, and inhalation pharmacotherapy. Higher standards are achievable with an increasing number of firefighters with medical education in service. Additionally, as the authors suggest, supplementary training for BLS rescuers should focus on practical exercises, using high-fidelity medical simulation [17].

The increasing number of medical interventions, including assistance to SMR entities and IMRE as independent interventions, means that medical rescue within the structures of SFS should develop with new equipment, procedures, and qualified staff to implement BLS procedures and experienced instructors for training [18].

Madziała [19] highlights that firefighters are the leading rescue service in Poland, often being the first to undertake BLS actions and importantly, operate in danger zones, implementing medical care during the evacuation of victims from hazardous areas where medical teams lack access due to security measures.

Activities beyond BLS can be performed by firefighters with medical rescuer qualifications, as noted by Krzyżanowski [20]. This is enabled by the amendment to the SMR Act [21]. According to the amendment, a medical rescuer can work professionally in entities other than SMR e.g., fire protection units. Among the 2015 changes, the range of activities and equipment was expanded, including instrumental airway clearance techniques, which are consistent with the methodology of the present study. 2015 can be seen as the beginning of the use of SAD in the fire brigade in Poland.

The use of SAD in the Polish police is described by Bielecka in the context of BLS training in police schools, with particular emphasis on supraglottic methods. The author lists BLS course participants, which can include firefighters, police officers, and specific civilian groups. Internal regulations obligate police officers to provide BLS, training, and recertification of qualifications, similar to professional and volunteer Polish firefighters [22, 23].

Limitations

The study has limitations related to the small population that participated in it. It would be interesting to compare firefighters after the CPR course versus firefighters with medical education. This could be a future study concept using this methodology. The quality of other key elements of resuscitation was not assessed:

— the effective time of establishing the supraglottic method (I-gel mask, size No. 4 — for an adult weighing 50–90 kg);
— chest compressions.

The order of study stages was intentional (stage 1 vs stage 2). The aim of the study was not to assess the effectiveness of ventilation itself, but mainly the impact of monitoring equipment on ventilation results. To achieve this, a study was performed using two series of results as related (dependent) variables. This pairing and calculation of differences gives us information about the difference in the results of the examined people than the information which would be obtained using two separate groups (student t-test for unrelated variables). Undoubtedly, the use of randomization would have a beneficial effect on minimizing the effect of familiarization with the mannequin. Due to the fact that stages I and II were not randomized, which would improve the quality of the study (minimizing the familiarity effect), this concept may be used in the future in studies on a larger population of firefighters (in other regions of Poland).

CONCLUSIONS

The practical utilization of medical equipment should be regular to maintain the initial skills at a high level before facing more challenging real-life operations where stress, difficult terrain and weather conditions, as well as time pressure, are encountered. It is necessary to introduce more training and practical exercises utilizing elements of medical simulation so that firefighters can practice the most difficult CPR procedures in conditions that are as realistic as possible. Software assistance and the possibility of real-time feedback significantly improve the quality of ventilation conducted by firefighters using SAD in terms of observed parameters. It is worth considering including in the composition of CPR rescue kits tools (devices) for assessing the quality of CPR, primarily in units that, according to statistics, carry out a larger number of independent medical rescue interventions.

Article information and declarations

Data availability statement

Original contributions presented in the study are included in the article — section 'Results'. The data that support the findings of this study are available from the corresponding author, L.Cz, upon reasonable request.

Ethics statement

The study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Ethics Committee No. 16/2022 ABNS. Firefighters participating in the study remained anonymous. The study was voluntary, and participants were informed about this.

Author contributions

Work concept and design, L.D.; data collection and analysis, L.D, M.K., T.K., K.M.; responsibility for

statistical analysis, L.C.; writing the article, L.D., M.K.; critical review, L.D., R.K.; final approval of the article, L.C.

Funding
No funding.

Acknowledgments
Voivodeship Commander of the SFS in Lublin and Olsztyn to conduct the study in the regions.

Conflict of interest
The authors declare no conflicts of interest.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 58–59
DOI: 10.5603/demj.98485

ISSN 2451–4691, e-ISSN 2543–5957

IMPLEMENTING DOUBLE SEQUENTIAL DEFIBRILLATION IN ACCORDANCE WITH THE 2023 ILCOR CONSENSUS

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KEYWORDS: double sequential defibrillation; DSED; defibrillation

Disaster Emerg Med J 2024; 9(1): 58–59

We enjoyed reading an article authored by Dabkowski et al. [1]. The authors of the paper emphasized the need to incorporate double sequential defibrillation (DSED) into the treatment recommendations, even if there is little data about its efficacy. Significantly, just a short period of time has elapsed between the release of the publication to the emergence of the most recent recommendations, titled "2023 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations" [2]. The 2023 Treatment Recommendations propose that adults experiencing cardiac arrest and still in ventricular fibrillation or pulseless ventricular tachycardia after receiving at least three consecutive shocks may consider using a DSED strategy or a vector change (VC) defibrillation strategy. These recommendations provide the first set of instructions that modify the approach to DSED and enhance its accessibility in prehospital care. Additional study is required to determine the superiority of the DSED technique and VC defibrillation strategy since the present data does not provide enough information to differentiate between each of them. Their clinical approval, however, allows their use and creates opportunities for a broader study of this issue. When using a DSED technique, it is recommended to utilize a method where a single operator activates the defibrillators in sequence — and we must remember this fact when considering the use of DSED so that the introduction of new techniques does not cause delays and problems. Special emphasis should be placed on the restriction stated in the recommendations, which states that the use of dual shocks necessitates the presence of two defibrillators, and this has ramifications for available resources. A potential resolution to this issue might include developing a defibrillator that incorporates the capability to do DSED utilizing a single device, without imposing any additional burden on the team. DSED is now used by a few EMS systems to treat refractory shockable cardiac arrest that is resistant to treatment, making it a feasible option for integration into certain systems. In other systems, this approach may need substantial allocation of new resources for extra defibrillators or ambulances, and such an increase in resource allocation might pose considerable challenges and incur high costs. It is important to note that COVID-19 infection may be linked to ventricular tachycardia or ventricular fibrillation storm, both during the acute and convalescent stages of the infection — so there may be more and more such rhythms for the use of DSED, even as cardiovascular complications of the COVID-19 [3]. We have plenty of evidence on how the pandemic has affected, for example, cardiac arrest or arrhythmias, and we know that this evidence has rather poor prognostic effects for the future [4–8]. Additional investigation into the use of DSED and proper equipment preparation is

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Received: 10.12.2023 Accepted: 17.12.2023 Early publication date: 1.02.2024

essential. With the introduction of new standards, however, there is a strong likelihood of widespread adoption and advancement of this approach.

Article information and declarations

Acknowledgments
Not applicable.

Conflict of interests
The authors declare no conflicts of interest.

Funding
None.

Supplementary material
None.

Author contribution
All authors are equally responsible for the preparation and final editing of the manuscript.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 60–61
DOI: 10.5603/demj.99169

ISSN 2451–4691, e-ISSN 2543–5957

NEUROLOGICAL IMPLICATIONS OF LONG-COVID-19 — CURRENT KNOWLEDGE AND THE NEED FOR IMPLEMENTING REMEDIES

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According to the Household Pulse Survey conducted by the Census Bureau, over 16.3 million individuals, which accounts for roughly 8% of working-age Americans, are now experiencing LONG-COVID-19. Out of the total number, around 2 to 4 million individuals are unemployed as a direct result of the long-term effects of COVID-19 [1]. Research conducted by Davis et al. [2] using data from 56 countries revealed that 22% of individuals suffering from LONG-COVID-19 had work incapacity as a result of their deteriorating health, while an additional 45% had to decrease their working hours. The prevalence of long-term and chronic neurological symptoms caused by COVID-19, often referred to as LONG-COVID-19, is attracting growing attention. These symptoms may last for many months or even years, impacting a significant number of individuals globally. LONG-COVID-19 often presents in previously asymptomatic persons, especially young adults, and may arise after a mild infection [3]. The most common, long-lasting, and debilitating symptoms of LONG-COVID-19 are related to the nervous system. A significant number of individuals experience fatigue and cognitive dysfunction, including decreased attention span, short-term memory loss, overall memory decline, language and motor skills impairment, decreased encoding and verbal fluency, and executive dysfunction [4]. Several symptoms that may be present include dysautonomia and post-exertional malaise. Post-exertional malaise is a condition characterized by severe tiredness and depletion of energy that people experience even after little physical exertion. Dysautonomia, a disorder marked by impaired functioning of the autonomic nervous system, may present with symptoms such as dizziness, rapid heart rate, high or low blood pressure, and gastrointestinal irregularities [5]. The physiological processes underlying neurological symptoms caused by COVID-19 infection are currently being elucidated. In addition to previously believed long-lasting inflammatory mechanisms, immune dysregulation, microbiota disruption, autoimmunity, clotting and endothelial abnormality, and dysfunctional neurological signalling — neuronal fusion is now considered a potential mechanism for the transmission and spread of the virus [6]. Preserving the distinctiveness of neurons is essential for the optimal operation of the nervous system. Studies suggest that COVID-19 might trigger the activation of viral fusogens, leading to the merging of brain cells in a way that cannot be reversed. This fusing of cells can disrupt the regular connection between neu-

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Submitted: 29.01.2024 Accepted: 06.02.2024 Early publication date 27.02.2024

rons, thereby explaining how the infection can lead to neurological problems. The impact on neuronal fusion will be contingent upon the viral load in the brain and the particular regions infected. For SARS-CoV-2, the fusing of neurons that occurs when they are infected relies on the presence of ACE2, the virus's cellular receptor, as well as other possible entry factors including TMPRSS2 and NRP1 in nearby neurons. Viruses like SARS-CoV-2 can induce the fusion of brain cells, which triggers aberrant behaviour and ultimately results in persistent neurological problems [7]. The administration of COVID-19 vaccines consistently decreased the likelihood of experiencing long-lasting symptoms of COVID-19, underscoring the significance of immunization in preventing persistent symptoms of the disease [8, 9]. The current Moderna and Pfizer-BioNTech vaccines include the whole S protein with two specific mutations — spike S-2P. These mutations involve the insertion of two prolines at locations 986 and 987. The presence of prolines in the protein enhances its structural stability and prevents it from merging with other cells. The spike protein S-2P of the vaccine has been shown to completely lack the ability to fuse with neurons. This unequivocally showcases the efficacy and reliability of mRNA vaccines concerning their safety [10]. Furthermore, it is imperative to establish explicit protocols for the care and handling of individuals experiencing LONG-COVID-19, and to establish specialized institutions specifically designed for the treatment of this particular ailment.

Information and declarations

Author contributions

All authors contributed equally to the manuscript.

Conflict of interest

None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No. 1, 62–63
DOI: 10.5603/demj.98660

ISSN 2451–4691, e-ISSN 2543–5957

CHRONIC CHALLENGES IN CHILDREN AND ADOLESCENTS FOLLOWING SARS-COV-2

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KEYWORDS: COVID-19; children; LONG-COVID-19

Disaster Emerg Med J 2024; 9(1): 62–63

While the occurrence of severe COVID-19 is less common in children compared to adults, there are at least two potential long-term consequences that may arise after a SARS-CoV-2 infection in children [1]. The repercussions include paediatric inflammatory multisystem syndrome (PIMS) and LONG-COVID-19. Asymptomatic individuals might experience both the effects of a coronavirus infection. Paediatric Inflammatory Multisystem Syndrome is a condition characterized by widespread inflammation affecting several organs in the body. This disease, which impacts 1 of approximately 3,000 children who get the virus require intensive care therapy in 68% of instances [2, 3]. LONG-COVID-19 is a complex and varied sickness that affects several systems in the body. It does not have a formal categorization yet, but it is defined by the persistence of signs and symptoms after infection with SARS-CoV-2 [4, 5]. A meta-analysis of 80,071 people ranging in age from 0 to 18 years revealed a prevalence rate of 25.24% for LONG-COVID-19 in children and adolescents. The five most often reported clinical complaints were mood symptoms (16.50%), fatigue (9.66%), sleep disorders (8.42%), headache (7.84%), and respiratory symptoms (7.62%). In addition, the occurrence of cognitive impairments in children, including reduced focus, learning difficulties, disorientation, and memory loss, was significantly greater compared to the control group. An important constraint of this meta-analysis was the absence of stratification of children into groups based on their COVID-19 vaccination status in any of the 21 studies included in the study [6]. The presence of LONG-COVID-19 presents a significant public health dilemma since there are currently no established protocols for its identification and treatment. Patients are essentially left to deal with this health condition alone, and the number of afflicted persons is steadily increasing. Research has shown that the pandemic has had a significant and far-reaching effect on children and adolescents. This influence manifests in several ways, such as impeding the development of children due to factors including social isolation, economic hardship, inadequate access to food, the loss of parental figures, disruption and limitation of educational opportunities, and heightened levels of stress. The COVID-19 pandemic has led to a significant increase in mental health issues, impacting both the general population and those who are recovering from LONG-COVID-19 sickness [7, 8]. Our objective should be to substantially decrease the prevalence of LONG-COVID-19 and its enduring consequences, while also implementing recommendations and therapeutic interventions for those struggling with it. Vaccinations might potentially reduce the prevalence of this illness, but they are not capable of eliminating it entirely [9]. The research revealed that children in the United States who were administered mRNA vaccinations for COVID-19 acquired a specific degree of immunity against the development of persistent symptoms after SARS-CoV-2 infection. Vaccination decreases the probability of encountering at least one persistent

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Received: 23.12.2023 Accepted: 31.12.2023 Early publication date: 16.12.2023

COVID-19 symptom by 34% and the frequency of two or more symptoms by 48% [10]. Establishing protocols is crucial for those struggling with the long-term effects of COVID-19 and their medical care. Additional study is important to determine strategies for mitigating the impact of the pandemic on children and adolescents, as well as safeguarding them against enduring problems of LONG-COVID-19.

Article information and declarations

Author contributions

All authors participated equally in the creation of the article

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

None.

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