SEPTEMBER 2024 | VOL. 9 | NO. 3

ISSN 2451–4691
E-ISSN 2543–5957

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DISASTER AND EMERGENCY MEDICINE JOURNAL

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tel: (+48 58) 320 94 94, fax: (+48 58) 320 94 60, www.journals.viamedica.pl/disaster_and_emergency_medicine

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TABLE OF CONTENTS

REVIEW PAPER

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EDITORIAL

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 133–135
DOI: 10.5603/demj.101692

ISSN 2451–4691, e-ISSN 2543–5957

EVALUATING THE RISK: GROUP A *STREPTOCOCCUS* AS A CAUSATIVE AGENT OF STREPTOCOCCAL TOXIC SHOCK SYNDROME AND NECROTIZING FASCIITIS

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KEYWORDS: *Streptococcus*; streptococcal toxic shock syndrome; STSS; necrotizing fasciitis

Disaster Emerg Med J 2024; 9(3): 133–135

Since 2022, several countries have shown a rise in the occurrence of severe invasive group A streptococcal disease (GAS), and this rise is a component of a broader escalation [1]. GAS bacteria are prevalent and may be transmitted by respiratory droplets or direct contact with infected individuals, carriers, or infected skin lesions. GAS is a bacterium that often leads to strep throat and skin infections. Severe GAS infection may progress to an invasive stage, indicating that the bacterium has spread to areas of the body where they are not typically present, such as the bloodstream, deep muscles, adipose tissue, or the lungs. However, it is crucial to be vigilant for indications of sepsis [2].

Streptococcal toxic shock syndrome (STSS) is an uncommon, severe and sometimes lethal illness linked to invasive or non-invasive GAS (especially *Streptococcus pyogenes*). STSS may manifest in conjunction with infection at any location, however, it most often arises in connection with an infection of a cutaneous lesion [3]. Characteristic features of toxicity include signs of poisoning and a fast-advancing clinical course, with a case fatality rate that may exceed 50% [4]. The first symptoms include fever and chills, muscular pains, as well as nausea and vomiting. Following this occurrence, STSS rapidly progresses, leading to hypotension, organ failure, tachycardia, and tachypnoea. STSS mostly affects individuals in the geriatric population and those with open wounds [4, 5].

According to the National Institute of Infectious Diseases (NIID), the data reveals that the incidence of STSS in Japan, as of March 25, 2024, exceeded the total number of cases reported in the preceding year. In 2023, there were a total of 409 STSS cases caused by GAS. For the first 11 weeks of 2024, there were 335 cases of STSS caused by GAS. Over the prior 6 years, the average number of notifications between weeks 1–11 was 77.5, with a range of 39 to 106. However, in 2024, there were 335 instances reported during weeks 1–11, which is the greatest number recorded thus far. The incidence of STSS

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Received: 22.07.2024 Accepted: 27.07.2024 Early publication date: 9.08.2024

cases attributed to GAS has shown a steady rise since July 2023, with further escalation seen in November, culminating in its zenith in January 2024, with a total of 165 reported cases. Notably, this surge in cases mostly affected those below the age of 50. Since November, there has been a rise in the number of notifications of instances involving individuals over the age of 50. The NIID further states that there was a rise in invasive GAS infections in the UK, France, Ireland, the Netherlands, and Sweden during the late 2022 and early 2023 period, but invasive GAS infections have stabilized in these nations by April 2023 [6].

STSS in Japan is also reportedly associated with another serious complication called necrotizing fasciitis (NF). In Western Europe, NF is roughly 1 case per 100,000 people, but in the US, it is 0.4. This illness usually affects adults and increases with age, reaching 12 per 100,000 in those 80 and older. NF infection is an infrequent but very severe type of bacterial infection. A very severe and often fatal kind of NF infection is caused by the bacterium *Streptococcus pyogenes*, also known as "flesh-eating bacteria" [7]. Necrotizing soft tissue infection occurs when there is a break in the skin, including wounds, surgical incisions, or even small scrapes, which allows infectious bacteria to enter the deeper layers of tissue called fascia [8]. The bacteria initiate proliferation and secrete toxins that induce tissue necrosis and disrupt blood circulation in the region. In cases of necrotizing fasciitis, the bacteria produce chemical compounds that inhibit the body's immune response to the pathogen. As the tissue undergoes necrosis, the bacterium infiltrates the bloodstream and proliferates quickly throughout the whole organism [7, 8].

As of March 2024, the incidence of STSS cases caused by GAS in Japan has significantly increased compared to previous years. It is imperative for healthcare providers to be alert in promptly identifying and treating STSS to enhance patient outcomes. Public health initiatives aimed at preventing STSS and necrotizing fasciitis include encouraging effective hygiene practices, such as appropriate wound management and hand cleanliness, as well as raising awareness among the general population about the indicators and symptoms of these infections. Timely identification and immediate action may greatly enhance the likelihood of recuperation and minimize the possibility of adverse outcomes — both STTS and necrotizing fasciitis are severe and possibly lethal conditions that need prompt medical intervention. The rising prevalence of these illnesses is a matter of concern, and endeavours should be undertaken to enhance awareness and adopt solutions to mitigate the dissemination of this lethal illness.

Article information and declarations

Acknowledgments
None.

Author contributions
All authors contributed equally to the preparation of the manuscript.

Conflict of interest
The authors declare no conflict of interest.

Funding
None.

Supplementary material
None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 136–137
DOI: 10.5603/demj.101763

ISSN 2451–4691, e-ISSN 2543–5957

OBESITY AND OUT-OF-HOSPITAL CARDIAC ARREST — A FATAL DUET

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KEYWORDS: obesity, semaglutide, bariatric surgery, return of spontaneous circulation (ROSC)

Disaster Emerg Med J 2024; 9(3): 136–137

We read with great interest the article by Fehler and colleagues [1] regarding the impact of obesity on the return of spontaneous circulation (ROSC) in out-of-hospital cardiac arrest. The study's main findings were that obesity decreased the odds of ROSC by approximately 10.6%. and was a significant negative predictor of ROSC. The authors emphasized that medical professionals face challenges in meeting European Resuscitation Council guidelines for patients with obesity, such as achieving the appropriate depth of chest compressions or inserting an intravenous line. Furthermore, the guidelines do not differ for obese patients compared to those of normal weight and do not provide specific recommendations for the obese patient population.

This issue is particularly concerning given the high prevalence of obesity worldwide. According to the World Health Organization (WHO), up to 13% of the world's population struggles with obesity [2]. Obesity promotes the incidence of life-altering and life-threatening health problems, such as type 2 diabetes, cardiovascular diseases and gastrointestinal cancer [3].

Obesity is not only an aesthetic problem or a risk factor, but a chronic disease on its own. In March 2021, the European Commission formally categorized obesity as a noncommunicable disease, emphasizing the need to combat it [4]. As lifestyle and behavioural interventions offer moderate efficacy, obesity treatment strategies should be intensified by adding pharmacological and/or surgical interventions [5].

Until the last few years, bariatric surgery, which results in 25–30% weight loss, was the only efficient option for obesity treatment. However, it is not scalable at the population level, and many individuals are bothered about postoperative complications [5]. Alternatives to bariatric surgery, such as intragastric balloons and endoscopic sleeves, are available but often temporary solutions recommended for patients with less severe obesity or as a bridge therapy for those awaiting bariatric surgery [6].

Until recently, achieving long-term weight normalization with pharmacotherapy posed significant challenges [7]. However, advances in understanding the mechanisms of weight regulation and the gut-brain axis's role in appetite control have led to the development of effective entero-pancreatic hormone-based treatments for obesity, such as glucagon-like peptide-1 (GLP-1) receptor agonists (GLP1R) [8]. GLP1R increases satiety, reduces food intake, delays gastric emptying, stimulates insulin release, and inhibits glucagon secretion in a glucose-dependent manner [5]. Recent clinical trials with GLP1R agonism are showing that breakthrough, drug-based management of obesity is possible [8]

The first GLP1R for obesity treatment liraglutide, was approved in 2014. In 2021, the US Food and

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Received: 2024-07-26 Accepted: 2024-08-07 Early publication date: 12.08.2024

Drug Administration approved semaglutide, a second GLP1R for use in addition to a reduced-calorie diet and increased physical activity, resulting in an average weight loss of ~15% after 68 weeks of treatment [9]. In patients with obesity and established cardiovascular disease but without diabetes, semaglutide reduced major adverse cardiovascular events compared to placebo in the SELECT trial. To overcome the barriers related to injections, semaglutide is also available in an oral form, with the 50 mg dosage resulting in 17.4% weight loss compared to 1.8% with placebo and improvements in cardiometabolic risk factors (OASIS 1 trial).

However, we would like to point out that despite the unquestionable benefits of GLP1R, they may not be beneficial in the situation of out-of-hospital cardiac arrest due to delayed gastric emptying, which is also an independent predictor of mortality [10]. Hence, all efforts should be made to achieve long-term weight loss and thus prevent cardiovascular complications before they lead to cardiac arrest in obese patients. If such patients experience cardiac arrest, with or without the treatment with GLP1R, their chances of survival are substantially lower than the chances of non-obese patients.

To summarize, obesity is a complex and chronic disease that requires a personalized and adaptive approach. Even those who meet treatment goals with new obesity medications might opt for subsequent bariatric surgery to maintain long-term weight loss or to avoid the need for life-long pharmacotherapy. On the other hand, bariatric surgery patients often experience inadequate weight loss or significant weight regain, necessitating further pharmacotherapy.

Considering the currently available plethora of options, a multimodal approach combining lifestyle interventions, pharmacotherapy, endoscopic therapies and bariatric surgery may help individuals achieve long-term goals and improve their quality of life. This comprehensive strategy should become the standard in obesity therapy, to prevent the fatal duet of obesity and cardiac arrest.

Article information and declarations

Authors contributions

All authors contributed equally to the creation of the manuscript.

Acknowledgments

None.

Conflict of interests

All authors declare no conflict of interest.

Funding

None.

Supplementary material

None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 138–139
DOI: 10.5603/demj.101658

ISSN 2451–4691, e-ISSN 2543–5957

THE EFFECTIVENESS AND SAFETY OF DASIGLUCAGON IN EMERGENCY MEDICINE

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KEYWORDS: hypoglycaemia; glycaemic control; treatment; dasiglucagon; emergency medicine

Disaster Emerg Med J 2024; 9(3): 138–139

Dear Editor,

dasiglucagon is a new form of glucagon analogue that has demonstrated potential in the treatment of insulin-induced hypoglycaemia, particularly in emergency scenarios involving individuals with type 1 diabetes mellitus (T1DM). If not properly addressed, severe hypoglycaemia is a serious and potentially life-threatening consequence of insulin therapy. Dasiglucagon overcomes certain drawbacks of traditional glucagon, such as its volatility in liquid state and the requirement for reconstitution prior to usage [1].

The American Diabetes Association (ADA) categorizes hypoglycaemia into three tiers, with severe hypoglycaemia necessitating prompt medical care [2]. Despite its success, traditional glucagon treatment faces limitations due to its chemical instability and the intricate delivery procedure. Dasiglucagon, which received approval from the USFDA in 2021, provides a stable and readily available option that can be administered rapidly, guaranteeing prompt therapy [3, 4].

A systematic review and statistical analysis of five randomized controlled studies, published until May 2023, assessed the effectiveness and safety of dasiglucagon in treating insulin-induced hypoglycaemia in individuals with type 1 diabetes mellitus. The main metric of interest was the duration of recovery, which was defined as the time required to increase plasma glucose levels to at least 20 mg/dL. It was found that dasiglucagon significantly shortened the time needed to recover compared to both the placebo (mean difference [MD]: –24.73 minutes) and oral glucose (MD: –15.00 minutes). Nevertheless, there was no statistically significant distinction between dasiglucagon and conventional glucagon (mean difference: –0.76 minutes) [5].

The investigation also evaluated the number of patients who experienced recovery at 10, 20, and 30 minutes after the intervention. At the 10-minute mark, dasiglucagon demonstrated a greater rate of recovery compared to placebo (odds ratio [OR]: 33.20) and oral glucose, but the difference was not statistically significant when compared to conventional glucagon (OR: 1.76). According to a study, dasiglucagon showed more effectiveness than placebo at both 20 and 30 minutes. However, there was no notable difference in efficacy compared to glucagon [6].

The safety research indicated that dasiglucagon was linked to a greater occurrence of treatment-emergent

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Date submitted: 2024-07-19 Date accepted: 2024-07-24 Early publication date: 14.18.2024

adverse events (TEAEs) such as nausea, vomiting, and headache in comparison to both placebo and oral glucose. Nevertheless, there was no notable disparity in the occurrence of treatment-emergent adverse events (TEAEs) between dasiglucagon and conventional glucagon. The research did not show any correlation between the occurrence of treatment-emergent adverse events (TEAEs) and the dosage administered [6].

A phase 3 trial demonstrated the efficacy and safety of a single subcutaneous dosage of 0.6 mg dasiglucagon in the treatment of severe hypoglycaemia in patients with type 1 diabetes mellitus (T1DM). The trial determined that dasiglucagon exhibited superior efficacy compared to both placebo and oral glucose, inducing prompt and enduring elevations in blood glucose levels. Nevertheless, its effectiveness was similar to that of traditional glucagon, with no notable disparities in safety profiles [6].

A separate study investigating the clinical effectiveness and safety of dasiglucagon in treating severe hypoglycaemia in patients with type 1 diabetes mellitus confirmed these results, emphasizing its fast-acting nature in increasing blood glucose levels and its positive safety record, which is similar to that of natural glucagon [7].

The main benefit of Dasiglucagon is its inherent stability in liquid form, which avoids the requirement for reconstitution prior to administration. This readily available formulation greatly decreases the time required for preparation and administration, which is vital in emergencies. The user's text states that the ease of use of a certain product or system has a positive impact on adherence to treatment procedures and outcomes for patients [4].

Dasiglucagon is a notable breakthrough in the treatment of insulin-induced hypoglycaemia in patients with type 1 diabetes mellitus (T1DM) [8]. Empirical research and comprehensive analysis validate its effectiveness and safety, establishing it as a potential treatment option for severe hypoglycaemia. Additional active-controlled noninferiority trials are necessary to definitively show the superiority of dasiglucagon over traditional glucagon. However, present findings indicate that dasiglucagon can be a dependable emergency treatment for diabetic patients [6, 9].

Article information and declarations

Funding

This research received no external funding.

Conflict of interest

The authors declare no conflict of interest.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 140–142
DOI: 10.5603/demj.101288

ISSN 2451–4691, e-ISSN 2543–5957

LARGE LANGUAGE MODELS IN EMERGENCY MEDICINE: POTENTIAL AND CHALLENGES

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KEYWORDS: large language models; LLMs; emergency medicine

Disaster Emerg Med J 2024; 9(3): 140–142

To the Editor,

large language models (LLMs), a subset of artificial intelligence (AI), are remarkably good at identifying, summarizing, translating, forecasting, and producing text and other content [1]. LLMs are very receptive to different prompts and inquiries and have a broad comprehension of the enormous volume of text data they have been trained on. With so many possible uses in the emergency department (ED), LLMs hold great promise for significant improvements in healthcare. This letter provides an overview of a future in which healthcare is more accurate, efficient, and patient-centred by pointing out places where incorporating these LLM AI developments into emergency medicine situations can be advantageous.

Large language models (LLMs) have the power to transform several emergency department (ED) processes. By examining patient data — including medical history, symptoms and test results — these powerful AI systems can deliver evidence-based recommendations for diagnosis and therapy in real-time [1]. This capacity can increase decision-making speed and accuracy in the hectic ED setting. Using main complaints and other relevant information, LLMs can create triage algorithms to rapidly determine patient acuity [2, 3]. Such algorithms may shorten waiting times and enhance results by giving priority to patients who need immediate attention. A priori LLMs should not exhibit any form of bias and therefore might be more objective in certain conditions, as it was described that some ED workers have strong prejudices that could affect patients' treatment — for example, homophobic attitudes can relate to incorrect attribution of symptoms to sexually transmitted diseases, ignoring a true cause of the complaint [4].

In one of the studies, ChatGPT could correctly assess patients in the emergency department according to their main complaints. Medical report generation and other clinical documentation management can also be automated by LLMs [1], which relieves doctors of administrative duties and saves them a great deal of time. Bradshaw [5] proposed that ED discharge instructions received by the patients may successfully be generated using ChatGPT. LLMs can also build chatbots or virtual assistants to communicate with patients, respond to their queries and offer crucial medical guidance [1]. Particularly when patients have restricted instant access to healthcare professionals, this can increase patient involvement and happiness. Further helping to identify important data quickly is LLMs' ability to extract and summarize important findings from radiological reports [6].

Although large language models (LLMs) have a lot of potential in the healthcare industry, adoption of them will need to overcome several obstacles. Addressing data privacy and security issues requires

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Received: 24.06.2024 Accepted: 8.07.2024 Early publication date: 2.08.2024

ensuring adherence to laws like Health Insurance Portability and Accountability Act (HIPAA) and safeguarding patient data anonymously [7, 8]. Considered "black boxes", many LLMs are opaque in their decision-making processes, which can impede physicians' adoption and trust [2, 8, 9]. LLMs run the danger of sustaining prejudices in their training data, which could result in differences in treatment. Various, representative datasets and close monitoring are necessary to lessen this [1, 8, 9]. The need to stress that LLMs should support the human experience rather than take its place is essential to preserve the professional worth of healthcare practitioners. Clinical judgment and critical thinking abilities run the danger of declining if physicians become unduly dependent on LLMs, even if they can improve clinical decision-making. Using LLMs presents intricate medical and ethical issues about accountability for mistakes and guaranteeing just and moral AI application [8, 9]. Particularly in the medical industry where accuracy is essential, LLMs cannot always yield correct information [8]. LLM performance is mostly influenced by the calibre and representativeness of the training data. Untrustworthy or discriminating outcomes can occur from inaccurate or biased data [8]. What is more, for smaller or less resource-rich institutions, the financial burden of establishing and sustaining LLMs in hospital settings could be prohibitive [9].

LLMs have the potential to revolutionize emergency medicine by enhancing patient care, streamlining procedures, and improving clinical decision-making. Studies demonstrated that paramedics working in ED often experience mental overload, insomnia or burnout [10, 11]. Interventions leading to relieving their occupational burden or saving time might contribute to all, as it was proven that strategic management of human resources positively influences employees, their satisfaction and engagement. Notwithstanding, ED healthcare providers must feel secure to deliver optimal care [12]. Therefore, they must be certain that new technologies implemented in the ED are reliable and trustworthy.

There are multiple important issues to consider, such as the need for model interpretability, data privacy concerns, and the potential for bias in training data. Addressing these issues is critical as research in this area advances to guarantee the safe, efficient, and fair application of LLMs in the emergency department. Medical practitioners play a vital part in this process since their knowledge and experience are priceless in directing the integration of LLMs in emergency medicine.

Article information and declarations

Acknowledgments

None.

Author contributions

All authors participated equally in the creation of the article.

Conflict of interest

The authors declare no conflict of interest.

Funding

None.

Supplementary material

None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 143–144
DOI: 10.5603/demj.101493

ISSN 2451–4691, e-ISSN 2543–5957

ARTIFICIAL INTELLIGENCE APPLICABILITY IN EMERGENCY DEPARTMENTS — A NEW PROMISING TOOL

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KEYWORDS: artificial intelligence; emergency medicine; triage; electrocardiography; radiology

Disaster Emerg Med J 2024; 9(3): 143–144

Dear Editor,
in this letter, we highlight some recent advancements in the use of artificial intelligence (AI) in emergency medicine. With the recent leap in AI development, a significant number of opportunities for its usage have emerged. Its ability to process vast amounts of data, far exceeding human capacity, carries the potential to revolutionize emergency department management. This can be especially beneficial in situations where the number of patients exceeds available resources, allowing for a fast and accurate assessment of patients when needed.

AI has proven its effectiveness in triaging patients in emergency departments. Based only on the information documented in notes from emergency department admissions, AI was able to determine which of the two patients required more urgent medical attention 89% of the time, a performance comparable to that of resident physicians [1]. Another study on the potential use of a large language model (LLM) in patient triage showed an almost perfect agreement between the decisions made by GPT-4 and the triage team, as well as between GPT-4 and the gold standard in five emergency department areas [2]. In time-limited tasks, the effectiveness of GPT-4, Gemini, and emergency medicine specialists was compared. The results showed the superiority of GPT-4 in the correct triage rate compared to Gemini and the triage team [3].

Another useful aspect in the context of an emergency department is the use of AI in electrocardiography (ECG) analysis. A significant reduction in mortality was demonstrated through the use of an AI-enabled ECG alert system that identifies patients at high risk of mortality and communicates this information to physicians [4]. Additionally, in a study comparing GPT-4 with cardiology and emergency medicine specialists based on answers to 40 questions related to each analyzed ECG recording, GPT-4 demonstrated superior performance compared to both groups of physicians [5].

Promising results are also provided by studies focused on the potential application of AI for evaluating radiological images. According to its authors, the first AI study to evaluate chest radiographs in clinical conditions showed the sensitivity and specificity of AI reports in detecting any abnormalities to be 84.8% and 98.5%, respectively, compared to the sensitivity of 91.5% and specificity of 97.0% for teleradiology for the same task. Particularly, the specificity of the

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Received: 8.07.2024 Accepted: 15.07.2024 Early publication date: 2.08.2024

study using AI gives hope for using such tools to prioritize examinations with high confidence [6]. Staying on the topic of imaging studies evaluation, a large meta-analysis considering 23 studies and over 34,000 patients demonstrated the effectiveness of deep learning algorithms in the assessment of pneumothorax with a pooled sensitivity and specificity level of 87% and 95%, respectively [7].

Another potential assistance from AI tools could be the prediction of complications in diagnosed diseases in patients admitted to hospital emergency departments. The first real-time prediction AI model implemented into the hospital information system for predicting complications of acute pancreatitis showed favourable initial results [8]. Even more interesting was the study aimed at creating an artificial neural network (ANN) and comparing its effectiveness with two machine learning algorithms, random forest (RF) and logistic regression (LR), in the early prediction of major adverse cardiac events (MACE) in patients admitted to the hospital emergency department. The differences in the effectiveness of classifiers for predicting MACE were minimal, with the highest sensitivity for RF at 99.4% and the highest specificity for ANN at 94.5% [9].

The above-mentioned articles show artificial intelligence's potential for revolutionizing emergency care by enhancing diagnostic accuracy, optimizing workflows, and enabling proactive patient monitoring. There are still some limitations that need to be acknowledged, including ethics, the black-box nature of AI, small training datasets, and algorithmic bias. The results obtained using these solutions still need human verification and should be independently interpreted. Further research and development are needed to overcome these deficiencies and establish transparent protocols. Despite this, the capabilities of AI improve significantly year by year, leading to increasingly better study results. Therefore, it seems crucial to monitor technological advancements, which may soon provide tools useful in everyday medical practice.

Article information and declarations

Acknowledgments
None.

Conflict of interest
The authors declare no conflict of interest.

Funding
None.

Supplementary material
None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 145–146
DOI: 10.5603/demj.101584

ISSN 2451–4691, e-ISSN 2543–5957

CHEST COMPRESSION TECHNIQUE FOR INFANTS AND NEONATES — WHERE ARE WE?

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KEYWORDS: two-thumb technique; two-finger method; infant; neonate; chest compression

Disaster Emerg Med J 2024; 9(3): 145–146

To the Editor,

The necessity of developing a new chest compression technique for infants and neonates has become increasingly apparent due to the limitations of the current methods. Both the two-finger technique (TFT) and the two-thumb encircling hands technique (TTT) are essential in neonatal resuscitation, yet each has significant drawbacks impacting their effectiveness and the physical strain on the rescuer [1, 2]. This text explores the limitations of these techniques and underscores the need for a more efficient and less physically demanding method.

The TFT involves using the middle and ring fingers to compress the lower half of the sternum. Despite its straightforward approach, TFT often results in inconsistent compression depth, which can compromise the quality of cardiopulmonary resuscitation (CPR) [3]. Research, such as the study by Christman et al. [4], has shown that the two-thumb technique achieves greater depth and less variability in compressions compared to TFT. Additionally, TFT requires significant finger strength and endurance, leading to rescuer fatigue during prolonged resuscitation efforts. Proper finger placement is also a challenge, with many providers failing to position their fingers correctly, further reducing the method's effectiveness.

Conversely, the TTT, which involves encircling the chest with both hands and compressing with the thumbs, generates higher systolic pressures and more consistent compressions. Various studies have demonstrated the preference for this method due to its ability to produce deeper and more uniform compressions. For instance, studies have demonstrated that TTT generates higher systolic pressures, which are crucial for effective resuscitation. However, TTT also has its limitations. The encircling nature of TTT can restrict chest recoil and ventilation, potentially reducing the overall effectiveness of CPR. Jahnsen et al. [5] found that TFT achieved higher tidal volumes and minute ventilation compared to TTT, highlighting a significant drawback of the latter. Furthermore, maintaining the encircling position can cause hand pain and discomfort over time, impacting the rescuer's performance.

Given these limitations, there is a clear need for a new chest compression technique that addresses these issues. An ideal method should ensure effective compressions with consistent depth and minimal variability, optimizing the chances of successful resuscitation. It should also minimize physical strain and fatigue on the rescuer, allowing for longer and more effective performance. Reducing hand pain and discomfort is crucial to maintaining proper technique

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Received: 14.07.2024 Accepted: 18.07.2024 Early publication date: 2.08.2024

and continuing resuscitation without compromising performance [6].

Several potential solutions could be explored to develop a new technique. Mechanical assistance devices, for instance, can help maintain consistent compression depth and reduce physical strain. These devices can be designed to ensure proper alignment and pressure distribution, improving CPR efficiency. Additionally, ergonomically designed tools that fit comfortably in the rescuer's hands can help distribute force more evenly, reducing hand pain and improving comfort [7]. Hybrid techniques that combine elements of both TFT and TTT or introduce new hand positions can also be explored to maximize benefits while minimizing drawbacks [6, 8, 9].

In conclusion, developing a new chest compression technique for infants and neonates is essential to improving CPR effectiveness and reducing the physical toll on rescuers. By addressing the limitations of current methods and exploring innovative solutions, we can improve resuscitation outcomes and ensure that rescuers perform at their best during critical moments. Future research and clinical trials are necessary to identify and validate the most effective techniques and tools, leading to better survival rates and quality of life for neonates and infants in emergencies.

Article information and declarations

Acknowledgments
None.

Author contributions
The authors were equally involved in the preparation of this manuscript at all stages, including conception, literature collection and writing of the article.

Conflict of interest
All authors declare no conflict of interest.

Funding
None.

Supplementary material
None.

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VIA MEDICA

LETTER TO THE EDITOR

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 147–148
DOI: 10.5603/demj.102274

ISSN 2451–4691, e-ISSN 2543–5957

URGENT NEED FOR ENHANCED SURVEILLANCE AND RESEARCH ON NIPAH VIRUS

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KEYWORDS: Nipah virus; Paramyxoviridae virus; infections; epidemy

Disaster Emerg Med J 2024; 9(3): 147–148

Due to the COVID-19 pandemic, novel viral pathogens are now a global concern, and many epidemics continue. These outbreaks can become global threats due to globalization. In economically weaker nations, infectious diseases remain the leading cause of death, putting local healthcare systems under pressure and fostering new threats [1]. Nipah virus, an animal-transmitted pathogen, has a high mortality rate and can harm public health. Nipah is a Paramyxoviridae virus-like parainfluenza, measles, and mumps. Although less well-known than other infectious diseases, the Nipah virus poses a serious threat that requires global attention and intervention [2].

The Nipah virus was initially discovered during a disease outbreak in Malaysia in 1998. This outbreak led to 265 cases of acute encephalitis, resulting in 105 deaths between September 1998 and May 1999. The case fatality rate (CFR) during this period was 39% [3]. Subsequent outbreaks, primarily in Bangladesh, Malaysia and India, have demonstrated even higher mortality rates, ranging from 40% to 70% depending on the region. In Bangladesh, where the virus has caused near-annual outbreaks since 2001, the CFR has often exceeded 70% [4]. Between 1998 and 2018, over 600 cases of Nipah virus infection were reported, with significantly higher case fatality rates of 43–100% [5]. The Nipah virus was classified as a priority pathogen by the World Health Organization in 2022 because of its high mortality rate, lack of targeted treatment, absence of a vaccine, and frequent occurrence of outbreaks. The Nipah virus continues to be a significant concern in 2024. In January, two individuals from Bangladesh were diagnosed with Nipah virus infection, and regrettably, both of them died from the illness [6]. In July, a 14-year-old boy passed away, and 60 individuals belonging to the high-risk category were identified in Kerala, India [7].

The Nipah virus is transmitted to humans through direct contact with infected animals such as bats and pigs, or by consuming food that has been contaminated. In Malaysia, the primary cause of infection for the majority of human cases during an outbreak was contact with pigs. Furthermore, there have been confirmed cases of transmission of the virus from human to human, particularly in healthcare settings [4, 8]. This has raised significant concerns about the virus's ability to cause larger outbreaks. The clinical symptoms

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Recieved: 27.08. 2024; Accepted: 31.08.2024; Early publication date: 12.09.2024

of Nipah virus infection vary from absence of symptoms or mild respiratory illness to severe encephalitis, frequently resulting in fatality. The time required for incubation is typically shorter than two weeks. In the beginning, Nipah infection manifests as fever and headache, along with symptoms such as dizziness and vomiting. As the disease progresses, it can develop into severe encephalitis, which is marked by drowsiness, changes in consciousness, and coma. In addition to neurological symptoms, patients experience symptoms related to respiratory infection. Long-term neurological complications can have a significant impact on the quality of life of survivors [5, 9, 10]. Furthermore, the lack of targeted antiviral therapies or an approved vaccine renders the Nipah virus particularly concerning for public health.

Bats, the virus's natural hosts, can spread Nipah virus to humans, according to recent research [4]. Increased bat-human interactions, which increase spillover events, may be caused by land use, urbanization, and climate change. Not to be overlooked is the Nipah virus's ability to adapt and evolve, which could improve human transmission. Considering these factors, the international health community must prioritize Nipah virus research to develop effective diagnostic tools, treatments, and vaccines. Public health authorities must also improve surveillance systems, especially in outbreak-prone areas, and promote wildlife-human interaction reduction. The Nipah virus is a stark reminder of the threat of emerging infectious diseases. To prevent the Nipah virus from becoming a global health emergency, proactive strategies based on scientific research and international cooperation are needed.

Article information and declarations

Author contributions

Julia Krotofil — conceptualization, writing;
Oskar Szymanski — writing, review, editing;
Magdalena Grzesiak — writing, review, editing;
Michal Pruc — review, editing, language correction, supervision;
Lukasz Szarpak — review, editing, language correction.

Acknowledgments

None.

Funding

None.

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.3, 149–157
DOI: 10.5603/demj.100606

ISSN 2451–4691, e-ISSN 2543–5957

NAVIGATING MORTALITY PREDICTION IN SEVERE MALARIA: RISK STRATIFICATION MODELS FROM THE EMERGENCY DEPARTMENT OF COASTAL INDIA

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ABSTRACT

INTRODUCTION: Malaria, a pervasive infectious disease, remains a critical health concern worldwide, particularly in regions with high transmission rates. This study investigates demographic patterns and prognostic factors influencing outcomes in malaria patients presenting to the emergency department (ED).

MATERIAL AND METHODS: This retrospective cross-sectional study, conducted at ED of South coastal India, from September 1, 2017, to September 1, 2022, analysed data from approximately 12,000 annual visits. Mortality predictors were assessed in malaria-positive patients, including Shock Index (SI), Modified Early Warning Score (MEWS), Sequential Organ Failure Assessment (SOFA), Malaria Severity Index (MSA), Malaria Prognostic Score (MPS), Coma Acidosis Malaria (CAM) score, Respiratory and Bicarbonate-based CAM score (R-CAM and B-CAM), Glasgow Coma Scale (GCS), and GCRBS Score.

RESULT: Analysis of 114 severe malaria cases revealed higher mortality (21.1%) among older rural patients. Non-survivors exhibited elevated pulse rates (139.83 ± 7.43), lower blood pressure (systolic: 62.58 ± 28.27, diastolic: 47.33 ± 20.73), and impaired consciousness (GCS: 6.63 ± 1.69). GCRBS, MSA, and SOFA scores demonstrated exceptional predictive accuracy (AUC = 1.00).

CONCLUSIONS: Identifying crucial mortality predictors like MSA, MPS, CAM, and GCRBS scores in malaria patients can optimize ED management protocols effectively.

KEYWORDS: malaria; prognostic factors; emergency department; GCRBS

Disaster Emerg Med J 2024; 9(3): 149–157

INTRODUCTION

Malaria, a potentially life-threatening tropical disease caused by Plasmodium parasites, continues to pose a significant global health challenge [1]. In 2022, the worldwide burden of malaria remained staggering, with an estimated 249 million cases reported across 85 endemic countries and areas. This marked an increase of 5 million cases compared to the previous year, highlighting the persistent threat posed by the disease. Tragically, the mortality rate in the same year stood at 14.3%, underscoring the urgent need for improved prognostic tools and treatment strategies to combat this deadly disease [2].

Within the World Health Organization (WHO) South-East Asia Region, which accounts for about 2% of malaria cases globally, India emerged as a no-

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Received: 8.05.2024 Accepted: 9.07.2024 Early publication date: 9.08.2024

table hotspot, contributing to 66% of cases in the region. Alongside Indonesia, India accounted for approximately 94% of all malaria-related deaths in the Southeast Asia Region [2]. This disproportionate burden of malaria-related morbidity and mortality in specific regions, such as Southeast Asia and particularly India, emphasizes the critical need for effective interventions and management strategies [3].

Malaria presents a wide variety of symptoms, ranging from mild to severe, with potentially fatal complications. The disease can be categorized as uncomplicated or severe (complicated), with severe malaria-carrying a high risk of mortality. Major complications of severe malaria include cerebral malaria, severe anaemia, haemoglobinuria, pulmonary oedema acute respiratory distress syndrome (ARDS), acute renal failure, acidosis, and hypoglycaemia[4]. These complications can develop rapidly and progress to death within hours or days, highlighting the importance of prompt and accurate diagnosis and treatment [3].

Prognosticating the outcomes of malaria patients relies heavily on a combination of clinical and laboratory features, aiding in swift triaging and identifying those needing urgent critical care admission. Despite their proven effectiveness in critical care, some scoring systems like MSA (Malaria Score for Adults), MPS (Malaria Prediction Score), SOFA (Sequential Organ Failure Assessment), CAM (Coma Acidosis Malaria score), MEWS (Modified Early Warning Score), and GCRBS (Glasgow Coma Scale, Creatinine, Respiratory rate, Bilirubin, Systolic blood pressure) remain largely unexplored in resource-limited emergency departments (EDs). These scores, leveraging easily accessible clinical parameters and basic lab tests, offer a straightforward means of predicting mortality risk in severe malaria cases. Their simplicity streamlines decision-making without prolonged investigations [5].

While subjective elements in MSA and MPS may introduce observer bias, the quantitative nature of GCRBS and MEWS assessments of all parameters, potentially mitigate such biases. Given malaria's high global incidence, there's a pressing need for improved prognostic tools. This study aims to evaluate mortality predictors and outcomes in malaria patients, focusing on the efficacy of prognostic scoring systems in ED. Insights from this research could inform policy-making, promote standardized scoring system adoption, and enhance patient management protocols in EDs, ultimately improving malaria care.

MATERIAL AND METHODS

Study design and setting

The study, a retrospective cross-sectional analysis, gathered data from patients visiting the ED from September 1, 2017, to September 1, 2022. With an average annual visit of 12,000 cases, the authors specifically focused on patients presenting with smear-positive malaria parasites.

Inclusion criteria

— Patients who were diagnosed as smear-positive for malaria parasite arriving atthe ED.
— Patients of more than or equal to 18 years.

Exclusion criteria

— Patients less than 18 years.
— Incomplete records.
— Not a confirmed case of malaria.
— Patients with smear positive for malaria along with other tropical fever (e.g. Dengue, chikungunya, *etc*.).
— Patients partially treated at outside hospitals.
— Pregnant patients.
— Patients leaving against medical advice.
— Patientswho are known cases of chronic kidney disease, cirrhosis of liver disease, respiratory infection, and mental disorder were excluded from this study.

Study protocol

The records of patients who presented to the ED of KS Hegde Medical with fever were analysed and then the patients with smear-positive malaria were included in the study. The patients were assessed and stabilized by the primary survey where airway, breathing, circulation, disability and exposure were evaluated, adjuncts like arterial blood gas analysis (ABG), electrocardiography (ECG), capillary glucose level etc were used and patients were stabilized. For patients with threatened airways, they were intubated by rapid sequence intubation (RSI). Oxygen support to maintain partial pressure of oxygen above 80 mmHg. Mean arterial pressure was maintained above 60 by initial fluid bolus with intravenous (IV) normal saline (NS) at 20 mL/kg and switching over to vasopressor like Nor-epinephrine 0.05–0.1 mcg/kg/min. They were also started on antipyretic measures.

Demographic profile and clinical data along with vitals on arrival to ED were recorded. Basic blood investigations like complete blood count, renal function tests, liver function tests, coagulation profile

and fever workup for tropical fever workup (NS1 antigen, widal and IgM for leptospirosis) including peripheral smear for malaria parasite were sent from ED.

For each patient clinical scores like Shock index (SI), mean arterial pressure (MAP), Glasgow coma scale (GCS), MEWS and SOFAwere calculated from the primary survey [6, 7].

The severity of malaria upon presentation was evaluated based on several criteria. These included cerebral malaria, characterized by a GCS score of less than 10 or the presence of seizures; severe anaemia, indicated by a haemoglobin level below 5 g/dL; jaundice, identified when the total bilirubin level reached or exceeded 3 mg/dL; acute kidney injury, diagnosed with a serum creatinine level surpassing 3 mg/dL; shock, defined by a systolic blood pressure below 90 mmHg despite volume resuscitation or necessitating vasopressor support and pregnancy [4].

Then the six specific prognostic malaria scores were also calculated which are: MSA, MPS, CAM. Respiratory and bicarbonate rate-based CAM score (R-CAM and B-CAM), and GCRBS score, from the investigations sent from the ED on arrival [8–11].

Patients were shifted to ICU or ward, depending on the condition, after initial stabilization. The patients were followed until death or discharge and grouped as non-survivors and survivors respectively.

Outcome

The primary outcome was to assess the predicting factors of mortality and outcome of patients with malaria presenting to the ED. The secondary outcome was to determine the demographic profile of the patients with severe malaria incoastal south India.

Ethical consideration

The Institutional Ethical Committee Boardprovided the ethical clearance for this study which adhered to the principles of the Declaration of Helsinki concerning ethical principles in medical research.

Statistical analysis

Data analysis was conducted using the computer software SPSS version 23.0. Descriptive statistics were calculated, which include frequencies, percentages, means and standard deviations. Inferential statistics was done for comparison between survivors and non-survivors, using the Mann-Whitney U test, student t-test and Chi-Square/Fisher's Exact test is applied. The association between categorical variables was assessed using the chi-square test. The level of significance for all statistical analyses was set at 5%. Logistic regression analyses were conducted to explore the relationship between variables. The receiver operating characteristic curve (ROC) was employed to determine the optimal cutoff point, providing sensitivity, specificity, and the area under the curve (AUC) and value between 0.9–1 is considered excellent, 0.8–0.9 as excellent, 0.7–0.8 as fair, but 0.6–0.7 and 0.5–0.6 was considered as poor and fail as per academic point system. Statistical significance was defined as a p value ≤ 0.05.

RESULTS

There were a total of 3460 cases of fever with chills of various causes admitted during the study period. Among these,a total of 190 cases were identified as smear-positive for malaria. Among them, a total of76 cases were excluded from the study due to a few reasons: missing data (n = 42), leaving against medical advice (n = 6), partially treated by an outside hospital (n = 14), and patients with co-morbidities (n = 12).Two patients were diagnosed with concomitant dengue fever and thus were excluded. After applying the exclusion criteria, a total of 114 cases of malaria remained eligible for analysis.

Among the study group, 90 (78.9%) were survivors and 24 (21.1%) were non-survivors. Analysis revealed stark disparities between survivors and non-survivors across key demographic variables. Among the survivors, males comprised the majority, accounting for 84.6% of cases, while females represented a notable minority at 56.5% among non-survivors. Age-wise, notable distinctions, with a significant proportion of non-survivors falling into older age categories (> 60 years), constituting 57.9%. Moreover, residence emerged as a critical factor, with a substantial 88.1% of survivors hailing from urban areas contrasted with 30.9% of non-survivors residing in rural settings (Tab.1).

In comparing clinical parameters, non-survivors of severe malaria exhibited elevated pulse rates (139.83 ± 7.43) and diminished blood pressure metrics including systolic (62.58 ± 28.27) with diastolic (47.33 ± 20.73). They also showed lower mean arterial pressure (52.41 ± 22.94) and oxygen saturation (80.21 ± 4.22), along with elevated respiratory rates (27.96 ± 5.25) and body temperatures (103.13 ± 0.79). Glasgow Coma Scale scores were

Table 1. Demographic profile of malaria patients

Variable	Survivors n (n%)	Non-survivors n (n%)	Total n (n%)
Sex			
Male	77 (84.6)	14 (15.4)	91 (179.8)
Female	13 (56.5)	10 (43.5)	23 (20.2)
Age			
0–20 years	4 (100)	0 (0)	4 (3.5)
21–40 years	48 (82.8)	10 (17.2)	58 (50.9)
41–60 years	30 (90.9)	3 (9.1)	33 (28.9)
> 60 years	8 (42.1)	11 (57.9)	19 (16.7)
Residence			
Urban	52 (88.1)	7 (11.9)	59 (51.8)
Rural	38 (69.1)	17 (30.9)	55 (48.2)

Variable	Outcome	N	Mean ± SD	Min	Max	p value	Median
Age	Survivors	90	39.34 ± 14.23	18	75	< 0.001*	35.0
	Non-survivors	24	52.58 ± 21.67	25	87		59.0

Table 2. Clinical parameters in malaria on presentation to ED

Variables	Survivors (Mean ± Sd)	Non-survivors (Mean ± Sd)	p value
VITALS ON PRESENTATION TO ED			
Pulse Rate (bpm)	90.14 12.63	139.83 7.43	< 0.001*
Systolic BP (mmHg)	111.16 9.89	62.58 28.27	< 0.001*
Diastolic BP (mmHg)	77.034.52	47.33 20.73	< 0.001*
SpO2	94.914.47	80.214.22	< 0.001*
Temperature (^{O}F)	99.851.29	103.130.79	< 0.001*
Respiratory rate (cpm)	16.824.08	27.96 5.25	< 0.001*
Days of hospitalization	4.88 ± 1.45	1.89 ± 0.73	< 0.001
SCORING ON ED PRESENTATION			
MAP	88.40 4.87	52.41 22.94	< 0.001*
Shock Index (SI)	0.79 (0.72,0.89)[a]	1.88 (1.72,2.11)[a]	< 0.001*
GCS	12.501.72	6.631.69	< 0.001*

p value is statistically significant ($p < 0.05$); aMedian (Q1,Q3), Mann-Whitney U test is applied

significantly lower in non-survivors (6.63 ± 1.69), highlighting their impaired consciousness (Tab. 2).

In severe malaria cases, non-survivors showed significantly higher frequencies of Glasgow Coma Scale (GCS) scores < 10 (100%), seizures (16.7%), haemoglobin levels < 5 g/dL (98.2%), elevated total bilirubin (100%), and creatinine levels > 3 mg/dL (91.7% vs 6.7%) compared to survivors. Additionally, non-survivors had a higher incidence of requiring mechanical ventilation (83.3% vs 5.6%) and vasopressor support (41.7% vs 11.1%) (Tab. 3).

In non-survivors of severe malaria compared to survivors, there were significantly lower mean levels of haemoglobin (8.31 g/dL), total leukocyte counts (17,200 cells/mm^3), and platelets (65,500 cells/mm^3), alongside elevated total bilirubin (7.27 mg/dL), serum glutamic oxaloacetic transaminase (SGOT) (129.78 IU/L), serum glutamic pyruvic transaminase (SGPT)(142.5 IU/L), creatinine (3.7 mg/dL), international normalized ratio (INR) (2.70), lactate (6.25 mmol/L), and reduced bicarbonate levels (13.67 mEq/L) (Tab. 4).

Table 3. Assessment of severe malaria

Parameters	Survivors n (n %)	Non-survivors n (n %)	p value
Cerebral malaria	14 (15.6)	24 (100)	< 0.001*
Seizure	3 (3.3)	4 (16.7)	0.016*
Severe anemia	0 (0)	22 (98.2)	0.043*
Jaundice	5 (5.6)	24 (100)	< 0.001*
Acute kidney injury	6 (6.7)	22 (91.7)	< 0.001*
Ventilator	5 (5.6)	20 (83.3)	< 0.001*
Vasopressor	10 (11.1)	10 (41.7)	< 0.001*
Pregnancy	88 (97.8)	23 (95.8)	0.597
Metabolic acidosis	7 (7.8)	24 (100)	< 0.001*
Sinus tachycardia	6 (6.7)	24 (100)	< 0.001*

Table 4. Lab parameters in malaria

Parameters	Survivors (n = 90) Mean ± SD	Non-survivors (n = 24) Mean ± SD	p value
Hb	12.891.54	8.311.48	< 0.001*
TC	7300 (6500,8700)[a]	17200 (15225,18600)[a]	< 0.001*
Platelets	164000 (151500,19800)[a]	65500 (31000,87750)[a]	< 0.001*
T. Bilirubin	2.30 (2.0,2.5)[a]	7.27 (5.34,9.10)[a]	< 0.001*
SGOT	60.6111.49	129.7812.39	< 0.001*
SGPT	60 (52,70.25)[a]	142.5 (132,147.75)[a]	< 0.001*
Glucose	92.4015.62	80.6313.20	< 0.001*
Urea	33.7 (27.05,40.90)[a]	95 (86,104)[a]	< 0.001*
Creatinine	1.9 (1.08,2.20)[a]	3.7 (3.5,4.24)[a]	< 0.001*
Sodium	137.43 1.75	131.58 4.80	< 0.001*
Potassium	4.01 0.32	4.450.58	< 0.001*
Chloride	100.44 3.79	100.17 3.66	0.755
INR	1.20 (1.10,1.40)[a]	2.70(2.07,3.30)[a]	< 0.001*
Bicarbonate	23.011.93	13.672.40	< 0.001*
pH	7.320.10	6.910.23	< 0.001*
Lactate	1.30 (1.0,2.0)[a]	6.25 (1.92,9.37)[a]	< 0.001*

*p value is statistically significant ($p < 0.05$); [a]Median (Q1, Q3), Mann-Whitney U test, p value

In assessing the accuracy of mortality predictors, the area under the ROC curve was utilized. Among them, the GCRBS score stood out with remarkable performance metrics. It demonstrated perfect sensitivity (100%) and specificity (100%), accompanied by an impressive Area under the curve (AUC) of 1.00. Similarly, the MSA and SOFA scores showed outstanding predictive accuracy, with sensitivity and specificity both at 100% and AUCs of 1.00. In contrast, the CAM and BCAM scores displayed limited predictive value, with sensitivities of 97.78% and 100%, respectively, but no specificity (Tab. 5, Fig. 1).

DISCUSSION

Malaria, a mosquito-borne disease, is a significant global health challenge, with India and Indonesia notably contributing to the majority of cases and fatalities within the Southeast Asia Region. Malaria exhibits a wide spectrum of clinical presentations, ranging from mild, uncomplicated cases to severe forms, carrying a notable mortality risk of approximately 14.3% [2]. In the present study, the elevated mortality rates can be attributed to several factors specific to the coastal region of South India where the research was conducted. This area experiences

Table 5. Factors evaluated for mortality predictors in malaria patients

Predictors	Cutoff	Sensitivity	Specificity	AUC	PPV	NPV	Accuracy	p value
MPS	5	100%	98.89%	1.00	96%	100%	0.99	< 0.001*
MSA	3	100%	100%	1.00	100%	100%	1.00	< 0.001*
CAM	2	97.78%	0	0.36	78.57%	–	0.78	0.055
RCAM	3	100%	84.44%	0.92	63.16%	100%	0.87	0.025*
BCAM	2	100%	0	0.28	78.95%	–	0.78	0.049
GCRBS	6	100%	100%	1.00	100%	100%	1.00	< 0.001*
MEWS	8	91.67%	100%	1.00	100%	97.83%	0.98	< 0.001*
SOFA	9	100%	100%	1.00	100%	1005	1.00	< 0.001*

AUC — area under the curve, PPV — positive predictive value, NPV — negative predictive value

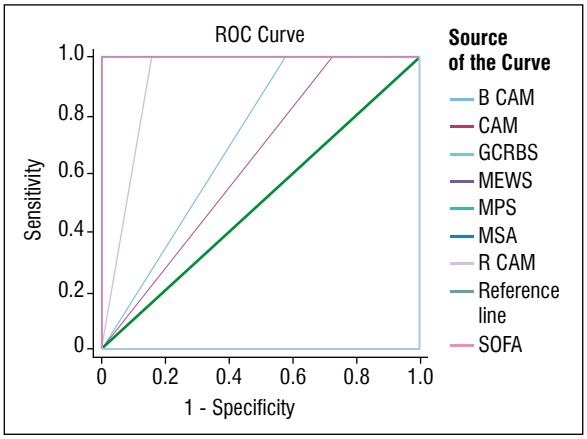

FIGURE 1. ROC cure for various mortality predictors in patients with malaria

a higher incidence of malaria due to poor housing conditions and environmental factors. Notably, periods of high temperatures and increased precipitation coincide with a surge in malaria cases, aligning with the breeding patterns of the Anopheles mosquito, the primary vector of malaria. Moreover, inadequate infrastructure and sewage systems in areas prone to heavy rainfall exacerbate the spread of the disease [12].

The present research unequivocally confirms that rural areas exhibit significantly higher mortality rates compared to urban areas, mirroring the findings of a study conducted in Nigeria by Ibinaiye et al. [13], where 61.1% of subjects hailed from rural communities. These results are further supported by a WHO report on malaria in Chhattisgarh, released in April 2023. The absence of comprehensive health education, coupled with the rural population's scepticism towards doctors and modern medicine, undeniably contributes to the surge in cases. Consequently, there is a lack of personal mitigation and prevention techniques, leading to a higher turnover rate of patients presenting late to healthcare facilities, exacerbating their conditions. These findings unequivocally underscore the urgent need for targeted interventions in rural areas to enhance access to healthcare services and curb mortality rates.

This analysis unveiled a significant gender disparity in malaria incidence, with males exhibiting a notably higher prevalence compared to females, as indicated by a male-to-female ratio of 3.9:1, consistent with findings from Abate et al.'s [14] study in Ethiopia in 2021. This discrepancy can be from the greater involvement of males in outdoor activities and occupational settings, leading to increased exposure to mosquito bites, coupled with the financial dependence of women on their male counterparts for healthcare access. However, in urban settings and developed nations, where women's empowerment and financial independence are more pronounced, these gender dynamics may evolve. Additionally, this study highlighted a higher prevalence among individuals aged 21–40 years, a demographic trend consistent with the findings of Abate et al. [14]. This pattern can be attributed to the heightened activity levels typical of this age group, particularly in outdoor settings. Socio-cultural and economic factors play a pivotal role in shaping the demographic profile of vector-borne diseases, underscoring the importance of targeted interventions tailored to specific population groups [15].

Clinical parameters are vital in triaging patients in ED, guiding management strategies and prognosticating outcomes in cases of malaria. However, limited studies have explored the correlation between vital parameters and point-of-care investigations

upon arrival with survival outcomes, particularly in ED. A study conducted in Udaipur, Rajasthan by Kumar et al. in 2007 sheds light on this aspect [2].They reported baseline vital parameters including systolic blood pressure (where 6% of patients with BP < 90 mmHg expired and 94% discharged with odds ratio of 12.81) respiratory rate (where in rate < 24 per minute had a mortality of 3.77% patients with rate > 24 had a mortality of 58.82% with OR of 0.027) and Glasgow Coma Scale (patients with GCS between 3 and 6 had 100% mortality, and a score between 11–15 had 3.63% mortality). The findings of the study are in line with the present where there was higher mortality in patients presenting to ED with tachycardia, hypotension and lower consciousness. Hypotension and shock in malaria may result in tissue hypoperfusion and hypoxia-induced increase in lactate [16].

When comparing severe malaria and mortality rates, significant factors included cerebral malaria (GCS < 10), anaemia (Hb < 5 g/dL), and acute kidney injury (creatinine level > 3 mg/dL). These findings align with a study by Geleta et al. [17] from Ethiopia, where 17.5% of patients had severe anaemia and among them, 1.7% had cerebral malaria. Notably, the study did not directly compare mortality rates among patients but focused on overall patient characteristics, specifically including children in the analysis.Anaemia in malaria can arise from various factors, including the destruction and reduced production of red blood cells mediated by TNF-alpha, as well as cell lysis during parasite replication, splenic removal, and autoimmune lysis of marked red blood cells [18].Cerebral malaria results from malarial rosettes trapping parasites in brain blood vessels, causing vasodilatation. Intense inflammation, including oxygen free radicals, IFN-gamma, and TNF-alpha, leads to cerebral congestion, reduced blood flow, endothelial cell activation, blood-brain barrier impairment, and cerebral oedema, increasing brain volume [19].

Comparing this study's laboratory parameters with those of a prospective study conducted in Cameroon, Central Africa, byNlinwe et al. [20] in 2018 sheds light on this aspect. Their research focused on baseline lab parameters of patients presenting to the outpatient department with malaria, revealing haemoglobin levels of 11.29 ± 2.50, a total leukocyte count of 7.391 ± 5.24, and platelet counts of 207.4 ± 127.6. Interestingly, the present study's survivor group showed similar findings. The presence of anaemia, leucocytosis, and thrombocytopenia is often linked with mortality. These conditions may arise from factors such as oxidative stress, splenomegaly, reduced production, or concomitant infections. Anaemia and thrombocytopenia may be secondary to oxidative stress and splenomegaly, while leucocytosis could be due to the redistribution of white blood cells or concurrent infections [21].

Elevated lactate levels in patients correlate with a higher likelihood of negative outcomes, mirroring the findings of Ishioka et al.'s [22] 2020 prospective observational study conducted in Bangladesh. Among the mortality group, lactate levels were recorded at 5.78 ± 1.61, while among survivors, levels were significantly lower at 2.95 ± 0.85. These findings align with the WHO Guidelines for Malaria released in 2021, which designate a plasma lactate level exceeding 5 mmol/L as indicative of severe malaria [23]. Elevated lactate production may be due to the metabolism of *Plasmodium* parasites, and increase anaerobic glycolysis in hypoxic cells and tissues due to parasite sequestration and anaemia. Compromised hepatic and renal lactate clearance which are often associated with underlying liver and kidney conditions, can exacerbate hyperlactatemia [24].

In the emergency department, prognostic indicators for malaria were examined. The MPS conducted by Santos et al.[9] in 2012 in Portugal revealed that survivors had a mean MPS of 1.78 (range: 0.38–4.53) while non-survivors had a mean MPS of 4.68 (range: 4.21–5.20), resulting in a significant palue of 0.008 and an AUC of 0.77 [9]. In the present study, the AUC was perfect, at 1.0 MSA score was extensively researched by Mishra et al. [8] in 2007 in Orissa India showed sensitivity is 89.9%, specificity of 70.6%, and positive predictive value is 94.1% when 5 is taken as the cut-off value.A similar result was found with a better sensitivity and specificity with AUC of 1 for MSA.

Hanson et al. in 2010 delved into the CAM and its associated scores using data from the SEAQUAMAT study [10, 25]. They noted that the CAM score had an AUC of 0.74 (95% CI, 0.67–0.82), while the BCAM score demonstrated an AUC of 0.79 (95% CI, 0.76–0.82), and the RCAM score showed an AUC of 0.68 (95% CI, 0.64–0.71) for predicting mortality [10]. The present analysis revealed a stronger correlation between RCAM and mortality. Notably, measuring base deficits requires access to appropriate laboratory facilities, which typically necessitate minimal maintenance.

The GCRBS score, comprising GCS, creatinine levels, respiratory rate, total bilirubin levels and systolic blood pressure (BP), emerges as a novel prognostic tool in clinical practice. This study indicates that a GCRBS score of 6 or higher is strongly correlated with elevated mortality, demonstrating exceptional sensitivity and specificity of 100%. This finding aligns with the observations of Mohapatra et al. [11] in Orissa, India, who established a similar threshold with a cutoff score of 5, displaying 85.3% sensitivity and 95.6% specificity. The consistent performance of the score across different studies underscores its potential as an invaluable aid for clinicians, particularly in critical care settings such as the ED, enabling precise prognostication and informed treatment decision-making to optimize patient outcomes.

Several additional factors can influence the severity of malaria, such as climate change, which impacts vector-borne disease transmission, but these were not included in the present study. The rainy season, spanning from June to October, significantly increases the transmission rate of vector-borne diseases. Kabir et al.'s [27] study from Bangladesh observed that the period from July to October is particularly sensitive for dengue cases due to higher relative humidity and lower wind pressure during these months.

This study has some limitations that need to be acknowledged. Primarily, the relatively small sample size and retrospective design introduce inherent biases including selection and information bias. Furthermore, this study was conducted in a tertiary care institute situated in coastal India, potentially limiting the generalizability of the present findings to broader healthcare settings. Additionally, it was not accounted for the specific parasite species and parasitaemia levels, which can significantly influence outcomes. To enhance predictive accuracy, future investigations should incorporate larger datasets, employ more sophisticated modelling techniques, explore novel biomarkers, and utilize advanced data collection methods. Despite these limitations, the present study provides valuable insights into prognostication in the ED for malaria patients, paving the way for further research and refinement of patient care protocols.

CONCLUSIONS

In summary, the present study delves into the nuanced clinical aspects of malaria patients, unveiling key demographic trends, clinical presentations, and predictive markers that influence patient outcomes in the ED. It underscores the pivotal role of identifying crucial mortality predictors like MSA, MPS, CAM and GCRBS scores which exhibit commendable sensitivity, specificity, and accuracy. The integration of these predictive markers into routine ED practices holds the potential to standardize protocols, particularly in regions burdened by malaria. By doing so, healthcare systems can optimize the management of malaria patients, ensuring prompt and effective interventions that ultimately alleviate the impact of this disease on public health.

Article information and declarations

Data availability statement

The authors agree to the conditions of the publication including the availability of data and materials in this manuscript.

Ethics statement

The study was approved by the Ethical Review Board. Nitte University ethics committee, number: NUSR2-22-019 and date: 28/12/2022). Written or verbal informed consent was not obtained from the patients as it was a retrospective study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.Written informed consent was not necessary because no patient data has been included in the manuscript.

Author contributions

Conceptualization, methodology and data collection, writing: Original Draft Preparation — MC; formal analysis, investigation, resources, writing:review &editing, supervision —SSVK.

Funding

This research received no specific grant from any funding agency in the public, commercial, or non-profit sectors.

Acknowledgments

None.

Conflict of interest

The authors declares that there is no conflict of interest.

Supplementary material

None.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 158–165
DOI: 10.5603/demj.101731

ISSN 2451–4691, e-ISSN 2543–5957

REVIEW OF COMPLAINTS ABOUT THE LATE ARRIVAL OF AMBULANCES

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ABSTRACT

INTRODUCTION: The arrival times of ambulances to the scene are a significant health quality indicator in terms of patient health and the public's trust in the system. In this study, it was reviewed whether complaints regarding ambulances are concentrated on certain days, hours, months, diagnoses, and triage codes. This study aims to contribute to the missing part of the literature and to improve emergency health services. Using these evaluations, pre-hospital health services can be assessed and required corrections can be implemented.

MATERIAL AND METHODS: This was a retrospective registrational study. Complaints sent to the 112 head physician offices by petitions and to SABIM (Ministry of Health Communication Centre) and CIMER (Republic of Türkiye Presidency's Communication Centre) online regarding the late arrival of ambulances in Ankara Province between 1 January 2021 and 31 December 2023 were reviewed. The data analysis was conducted using IBM SPSS 27.0 (Armonk, NY, USA: IBM Corp.).

RESULTS: The study included 161 complaints sent within three years. Of the complaints, 54.3% were made by males. The highest number of complaints was received in the summer months and the lowest number was in November. The highest number of complaints was made on Fridays. In 2022, the command reaction times were shorter than in the other years. Reaction and case arrival times in off-site cases were longer compared to those for in-site cases.

CONCLUSIONS: In this study, significant data were obtained about the active and effective use of 112 emergency ambulance services. Schedules should be drawn up taking into consideration the weekends and times when the number of patients is greater. Strategic arrangements can be made to utilize resources by reviewing previous data and complaints about ambulance systems. Such evaluations can be important sources for improving emergency healthcare services. Conducting these assessments and tasks regularly will inform future improvements such as reduced case transport times, reduced command reaction times and better pre-hospital care.

KEYWORDS: ambulance service; complaint; delay; reaction time; emergency healthcare

Disaster Emerg Med J 2024; 9(3): 158–165

INTRODUCTION

Pre-hospital healthcare services play a significant role in public health. Ambulances are one of the cornerstones of pre-hospital care. The 112-ambulance service used both for in-site cases and patient transfers,

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Recieved: 24.07.2024; Accepted: 07.08. 2024; Early publication date: 12.08.2024

was created to help patients and injured individuals access healthcare services as fast as possible [1].

Complaints received for a particular service play an important role in the development of that service. an important branch of pre-hospital health services is the 112-ambulance service. 112 ambulance service is the system that the public in Turkey uses to receive health care in any emergency. It serves a large number of ambulances and stations throughout the country. When the literature is examined, the number of studies examining the complaints made to ambulance services in Turkey is limited. This study aims to contribute to this missing part of the literature and to improve emergency health services [2].

In an emergency, reaction and response times are vital. Studies have shown that these times are closely related to mortality and morbidity rates [3, 4]. Speed and efficiency in emergencies are two important factors that affect the survival of patients. Moreover, ambulances, positioned at the centre of such services, enable the fastest and most suitable intervention for individuals who are experiencing health issues such as accidents, diseases, or injuries. They play a critical part not only in the transfer of patients but also in the first response at the scene.

The arrival times of ambulances to the scene are a significant health quality indicator in terms of patient health and the public's trust in the system. Maintaining the quality of the provided healthcare services is only possible through feedback and supervision. Complaints and feedback sent by the public, who receive healthcare services in the first place, are significant resources in enhancing the overall quality of the services. In the present study, the complaints made through petitions and online feedback systems for the Ankara Provincial Ambulance services over three years were evaluated.

MATERIAL AND METHODS

This was a retrospective registrational study. Complaints sent to the 112 head physician offices by petitions and to SABIM (Ministry of Health Communication Centre) and CIMER (Republic of Türkiye Presidency's Communication Centre) online regarding the late arrival of ambulances in Ankara Province between 1 January 2021 and 31 December 2023 were reviewed. The permission was obtained from the relevant institution for the study. Ethical approval was granted by the Scientific and Ethics Evaluation Committee for Medical Research No. 1 with TABED-1-24-284 number on 22.05.2024 at Ankara Bilkent City Hospital. The study included 161 complaints about the late arrival of ambulances on the specified dates. Due to the structure of the emergency healthcare services, patients of all ages and groups were included in the study. Groundless complaints and those with missing research parameters were excluded from the study. The data analysis was conducted with IBM SPSS 27.0 (Armonk, NY, USA: IBM Corp.). In addition to descriptive statistical methods (frequency, percentage, mean, standard deviation, median, interquartile range), the chi-squared test was used to compare quantitative data. The fit of the data to the normal distribution was evaluated through methods such as the Kolmogorov–Smirnov test, skewness and kurtosis, and graphical methods (histogram, Q-Q plot, stem and leaf, boxplot). Mann–Whitney U and Kruskal–Wallis tests were used for the comparisons between the quantitative data groups that do not have a normal distribution. Post-hoc Bonferroni correction was used in instances where the difference was found in multiple comparisons. The statistical significance level was set at $p = 0.05$.

RESULTS

This study included a total of 161 cases in which 112 emergency ambulance services were used over three years and a complaint was filed afterwards. The mean age was 48.4 ± 21.2. Furthermore, 36.6% of the complaints (n: 59) were received in 2021, 31.7% (n: 51) in 2022, and 31.7% (n: 51) in 2023. Regarding the days of the week, the highest number of complaints was made on Fridays (n: 37). Further, 85.7% of the complaints (n: 138) were on weekdays and 14.3% (n: 23) on weekends. While 57.8% of the patients attended (n: 93) were off-site, 42.2% (n: 68) were in-site. Looking at the reasons for calls, 81.4% (n: 131) were medical and 18.6% (n: 30) were trauma-related calls. On the other hand, the cases were finalized as transfer to hospital 89.4% (n: 144), transfer rejection 7.5% (n: 12), on-site intervention 1.9% (n: 3), and 3.1% (n: 2) death when the patient was left at the scene. Considering the diagnosis codes, the highest number of calls in specific diagnoses were trauma-related (18%, n: 29) (Tab. 1).

Command, station reaction times, and scene arrival times are provided in Table 2.

In the comparisons made based on years, a significant difference ($p < 0.05$) was found

Table 1. Characteristics of participants

		n	%
Year	2021	59	36.6
	2022	51	31.7
	2023	51	31.7
Seasons	Spring	38	23.6
	Summer	53	32.9
	Fall	39	24.2
	Winter	31	19.3
Months	January	10	6.2
	February	11	6.8
	March	12	7.5
	April	9	5.6
	May	17	10.6
	June	14	8.7
	July	14	8.7
	August	25	15.5
	September	20	12.4
	October	11	6.8
	November	8	5
	December	10	6.2
Day of the week	Monday	26	16.1
	Tuesday	19	11.8
	Wednesday	28	17.4
	Thursday	28	17.4
	Friday	37	23
	Saturday	14	8.7
	Sunday	9	5.6
Weekday/Weekend	Weekdays	138	85.7
	Weekends	23	14.3
Hour range	12 a.m.–07:59 a.m.	31	19.3
	08:00 a.m.– 03:59 p.m.	58	36
	04:00 p.m.– 11:59 p.m.	72	44.7
Work	Working hours	70	43.5
	Outside working hours	91	56.5
Sex	Female	75	46.6
	Male	86	53.4
Age (year) [Median (IQR)]			52.0 (30.0–65.0)
	< 18 Age	13	8.1
	≥ 18 Age	148	91.9
Region	Off-site	93	57.8
	In-site	68	42.2
Reason for Call	Medical	131	81.4
	Trauma	30	18.6

→

Table 1. Characteristics of participants (continued)

		n	%
Finalization	Transfer — to hospital	144	89.4
	Training and Research Hospitals	*79*	*54.9*
	Public Hospitals	*29*	*20.1*
	Universities	*21*	*14.6*
	Private Institutions	*15*	*10.4*
	Transfer — rejection	12	7.5
	On-site intervention	3	1.9
	Death — left at the site	2	1.2
Triage	Green code	51	31.7
	Yellow code	68	42.2
	Red code	37	23
	Black code	5	3.1
Diagnosis	Trauma	29	18
	Neurological complaints	25	15.5
	Psychiatric complaints	19	11.8
	Arrest	17	10.6
	Infectious diseases	14	8.7
	Cardiac complaints	13	8.1
	Gastrointestinal system	12	7.5
	Other system complaints	32	19.9

IQR — interquartile range

Table 2. Command, station reaction and scene arrival times

	Median (IQR)
Command reaction time (s)	246.0 (149.0–440.0)
Station reaction time (s)	42.0 (22.5–57.0)
Arrival Time – 1 (s) (Scene Arrival —Call)	675.0 (495.5–1.018.0)
Arrival Time – 2 (s) (Scene Arrival —Case)	363.0 (276.5–560.0)

between years in terms of Command Reaction Time and Arrival Time-1 values, and in two instances where differences were found, the reaction times in 2022 were shorter. No significant difference was found between years in terms of other variables ($p > 0.05$). In the comparisons made based on seasons, no significant difference was found in terms of all times ($p > 0.05$). In the comparisons made based on Weekday/Weekend, a significant difference ($p < 0.05$) was found between years in terms of Command Reaction Time and Arrival Time-1 values, and in two instances where differences were found, the reaction times on weekends were shorter. No significant difference was found in terms of other variables ($p > 0.05$). In the comparisons made based on the hour range, no significant difference ($p > 0.05$) was found in terms of hour ranges in terms of all times. In the comparisons made based on work status, a y significant difference ($p < 0.05$) was found between the work status in terms of Arrival Time-2 values, and the time outside the working hours was shorter. No significant difference was found in terms of other variables ($p > 0.05$). In the comparisons made based on sex, no significant difference ($p > 0.05$) was found between the sexes in terms of all variables. In the comparisons made based on age groups, no significant difference ($p > 0.05$) was found between age groups in terms of all variables. In the comparisons made based on regional status, a significant difference ($p < 0.05$) was found between regional status in terms of Command Reaction Time and Arrival Time-1 and -2 values, and in three instances where differences were found, off-site times were longer. No significant difference was found in terms of other variables ($p > 0.05$). In the comparisons

made based on the reason for calls, a significant difference ($p < 0.05$) was found between the reasons for calls in terms of Command and Station Reaction Times, and it was found that in reaction time trauma-related calls and in station reaction time medical calls were longer. No significant difference was found in terms of other variables ($p > 0.05$). In the comparisons made based on finalization, no significant difference ($p > 0.05$) was found between the finalization in terms of all times. In the comparisons made based on triage, no significant difference ($p > 0.05$) was found between triages in terms of all times. In the comparisons made based on the Transferred Hospital type, no significant difference ($p > 0.05$) was found between the transferred hospital types in terms of diagnoses (Tab. 3).

Table 3. Comparison of Reaction and Arrival Times

		Command Reaction Time (s)	Station Reaction Time (s)	Arrival Time-1 (s) (Scene Arrival — Call)	Arrival Time-2 (s) (Scene Arrival — Case)
Year	2021 (n = 59)	314	41	726	420
		(173.0–623.0)	(21.0–56.0)	(526.0–1.381.0)	(314.0–586.0)
	2022 (n = 51)	175	34	550	331
		(118.0–332.0)	(20.0–56.0)	(446.0–751.0)	(290.0–543.0)
	2023 (n = 51)	255	45	700	379
		(177.0–533.0)	(27.0–58.0)	(527.0–941.0)	(242.0–565.0)
	p*	**0.003**	0.378	**0.012**	0.348
	Difference	2 and 1–3	–	2 and 1–3	–
Seasons	Spring (n = 38)	269	35.5	811	375
		(174.5–536.0)	(25.8–57.0)	(544.3–1.180.3)	(260.8–598.8)
	Summer (n = 53)	228	42	589	356
		(127.0–385.0)	(24.0–59.0)	(441.5–972.0)	(266.0–542.5)
	Fall (n = 39)	293	45	695	420
		(148.0–516.0)	(21.0–55.0)	(502.0–1.368.0)	(290.0–610.0)
	Winter (n = 31)	222	45	638	350
		(150.0–384.0)	(17.0–56.0)	(456.0–917.0)	(285.0–495.0)
	p*	0.434	0.869	0.198	0.552
Weekday/ /Weekend	Weekdays (n = 138)	264	41	695	379.5
		(155.3–516.3)	(21.8–56.3)	(508.0–1.080.0)	(291.5–567.5)
	Weekends (n = 23)	192	50	543	350
		(110.0–281.0)	(33.0–58.0)	(437.0–720.0)	(225.0–394.0)
	p**	**0.048**	0.202	0.019	0.107
Hour Range	12:00 a.m.–07:59 a.m. (n = 31)	242	42	599	351
		(156.0–369.0)	(17.0–56.0)	(491.0–901.0)	(229.0–572.0)
	08:00 a.m.–03:59 p.m. (n = 58)	278	36	745	454.5
		(174.5–542.5)	(25.3–58.0)	(530.8–1.202.5)	(298.3–658.8)
	04:00 p.m.–11:59 p.m. (n = 72)	218	45.5	623.5	355
		(124.5–500.8)	(22.5–56.8)	(458.0–1.032.0)	(273.8–489.0)
	p*	0.39	0.84	0.086	0.084
Work	Working Hours (n = 70)	256.5	40.5	705	422
		(165.8–515.3)	(21.8–58.5)	(499.8–1.095.5)	(299.8–601.0)
	Outside Work Hours (n = 91)	242	43	638	349
		(139.0–419.0)	(24.0–56.0)	(491.0–1.003.0)	(250.0–496.0)
	p**	0.656	0.814	0.248	**0.027**

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Table 3. Comparison of reaction and arrival times (Continued)

		Command Reaction Time (s)	Station Reaction Time (s)	Arrival Time-1 (s) (Scene Arrival — Call)	Arrival Time-2 (s) (Scene Arrival — Case)
Sex	Female (n = 75)	259	42	710	385
		(156.0–517.0)	(24.0–57.0)	(501.0–1.169.0)	(271.0–576.0)
	Male (n = 86)	237.5	41	636.5	360
		(145.3–404.0)	(21.8–56.3)	(492.5–932.0)	(279.3–546.0)
	p**	0.463	0.988	0.212	0.36
Age Group	< 18 Age (n = 13)	160	46	654	362
		(105.5–524.0)	(28.5–57.5)	(440.0–968.5)	(291.5–706.5)
	≥ 18 Age (n = 148)	256	41	678.5	364
		(153.8–433.3)	(22.0–56.8)	(501.3–1.037.0)	(270.3–553.0)
	p**	0.263	0.479	0.495	0.763
Region	Off-site (n = 93)	279	41	742	420
		(175.5–549.0)	(24.0–58.0)	(544.0–1.194.5)	(305.5–613.0)
	In-site (n = 68)	221.5	42	560.5	322
		(122.5–386.3)	(18.0–55.8)	(428.3–796.8)	(235.3–432.0)
	p**	0.046	0.462	0.001	0.001
Reason for Call	Medical (n = 131)	234	45	654	363
		(140.0–404.0)	(26.0–58.0)	(491.0–1.003.0)	(285.0–542.0)
	Trauma (n = 30)	376.5	27.5	732.5	364.5
		(175.8–827.8)	(17.0–47.3)	(524.3–1.427.3)	(205.0–584.5)
	p**	0.036	0.014	0.165	0.965
Finalization	Transfer — to hospital (n = 144)	244	41	694	368
		(148.5–515.8)	(22.0–57.0)	(491.5–1.066.3)	(270.3–575.0)
	Transfer — Rejection (n = 12)	283	47.5	622	333
		(175.8–397.5)	(24.3–54.3)	(470.5–679.8)	(248.8–365.0)
	On-site Intervention (n = 3)	143	60	638	480
		(108.0–0.0)	(32.0–0.0)	(588.0–0.0)	(452.0–0.0)
	Death — Left at the site (n = 2)	260.5	30.5	651	390.5
		(228.0–0.0)	(1.0–0.0)	(589.0–0.0)	(361.0–0.0)
	p*	0.655	0.568	0.628	0.393
Triage	Green Code (n = 51)	227	42	609	350
		(143.0–455.0)	(25.0–57.0)	(464.0–1.107.0)	(261.0–495.0)
	Yellow Code (n = 68)	237	42	688	387.5
		(150.8–516.8)	(24.8–56.0)	(494.3–1.037.0)	(286.3–541.5)
	Red Code (n = 37)	266	33	695	362
		(120.0–402.5)	(14.0–57.0)	(479.0–926.0)	(261.5–604.0)
	Black Code (n = 5)	293	60	941	572
		(253.5–461.0)	(17.5–77.5)	(651.0–1.239.5)	(390.5–823.5)
	p*	0.795	0.567	0.63	0.256

*Kruskal–Wallis Test [Median (IQR)] ** Mann–Whitney U Test [Median (IQR)]

DISCUSSION

An important part of the pre-hospital healthcare services is the 112 ambulance service. Reaching patients and reaction times are closely related to the mortality and morbidity of patients [3]. Studies have shown a correlation between the time patients

spend in an ambulance and their mortality rates [4]. Therefore, it is essential that previous cases are evaluated while arranging ambulance services and plans are made in accordance with these evaluations so that resources are utilized effectively.

Alarilla et al. [5], in 2022, stated that people in England are waiting for an ambulance longer than ever, and revealed the target response time for the most critical calls was 7 min, the patients waited an average of 8.5 minutes in 2021/22, and this number was almost one fifth longer than they would have waited in 2018/19 . Moreover, the waiting period for less urgent cases where ambulance response is required increased more than double, reaching an average of 3 h. The present study, however, showed that, unlike the literature, command reaction times in 2022 were shorter than those in 2021 and 2023 ($p < 0.03$). The reason behind this could be increasing ambulance and call centre services. However, due to increased demand, the waiting duration for ambulances is increasing both in Türkiye and in the rest of the world.

Cantwell et al. [6], who discussed the time distribution of emergency calls, found the command reaction times to be longer on weekends compared to on weekdays. They stated that emergency calls displayed a bimodal distribution with the highest numbers of calls at 10:00 a.m. and 07:00 p.m. in the daytime. They revealed that the highest number of cases was on Fridays and the lowest on Tuesdays and Wednesdays. The distribution on Fridays, Saturdays, and Sundays was significantly different from that on the rest of the days ($p < 0.001$). They found that the trauma cases were highest on Friday and Saturday at midnight [6]. Al-Thani et al. [7], on the other hand, showed similar results to the present study, namely a shorter reaction time of call command reaction on weekends. Most of the cases occurred on weekdays. The present study showed that the call durations were significantly shorter on weekends than on weekdays. These differences might have occurred due to accessible and increased emergency healthcare services on weekends in Türkiye. In addition, the traffic density on weekends in cities was less dense compared to that on weekdays, which might have caused a shorter patient arrival time. Zang et al. [8] also found less traffic density on weekends than on weekdays. This study also supports the authors' opinion on the matter. The authors think that planning the emergency call services by reviewing these demands and distributions can help improve durations.

Al-Thani et al. [7], in their study in which they reviewed emergency calls, found that the time spent at the scene and the total pre-hospital time were especially higher in rural areas. They only studied patients with trauma-related calls and found that the mean response time, the time spent at the scene, and the total pre-hospital time were 6, 21, and 72 min, respectively. Similarly, the present study found the in-site command reaction time and arrival time to be significantly low.

Ibsen et al. [9], who studied the reasons for 112 calls, found that the most frequent five reasons for calls were chest pain, unknown issues, accidents, possible stroke, and shortness of breath. Lo et al. [10], who reviewed classified (valid) ambulance calls, stated that traumatic injuries and general medical issues made up a large portion of the calls. Traffic accident-related trauma is the primary reason for ambulance service calls. The second and third reasons are injury or bleeding and syncope with loss of consciousness, respectively [10]. Similar results to the literature were found as well. Although the number of medical calls was high, the command reaction time and arrival time in trauma-related calls were significantly shorter than in medical calls. Stojek et al. [11], who discussed trauma triage in the pre-hospital process, stated that, based on the severity of the injury, triage can be challenging in the pre-hospital care for patients who have been seriously injured. Poorly defined triage algorithms can lead to the trauma team intervening unnecessarily (over-triage), causing ineffective consumption of financial and human resources. A pre-hospital triage algorithm must be able to reliably identify patients who have experienced bleeding or severe brain injuries. Trauma is still one of the most frequent reasons for mortality across the world. Pre-hospital bleeding control and early intervention are crucial parts of providing care [11].

Considering the triage codes of the collected complaints, the highest number of red codes was observed in trauma patients. Additionally, the highest number of complaints about late arrival of the ambulance was once again seen in patients diagnosed with trauma. The authors think that such results were obtained because trauma cases are unexpected, can affect all age groups, and have a possible poor outcome. Mohta et al. [12] stated in their research that in order to finalize the treatment

process positively, it is necessary to provide psychological care in addition to physical treatment for patients who are treated in hospitals due to trauma.

CONCLUSIONS

In the present study, important data were obtained about the active and effective use of 112 ambulance services. Schedules should be drawn up taking into consideration the weekends and times when the number of patients is higher. Strategic arrangements can be made to utilize resources by reviewing previous data and complaints about ambulance systems. Such evaluations can be important sources for improving emergency healthcare services. Conducting these evaluations and tasks regularly will shed light on future developments.

Article information and declarations

Data availability statement

Data regarding our study can be accessed from Ankara Provincial Health Directorate, Emergency Health Services, Türkiye.

Ethics statement

Ethical approval was granted by the Scientific and Ethics Evaluation Committee for Medical Research No. 1 with TABED-1-24-284 number on 22.05.2024 at Ankara Bilkent City Hospital.

Author contributions

Study conception and design: Ramiz Yazıcı; data collection: Ramiz Yazıcı, Murat Genç; analysis and interpretation of results: Ramiz Yazıcı, Murat Genç; draft manuscript preparation: Murat Genç. All authors reviewed the results and approved the final version of the manuscript.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgements

Not applicable.

Conflict of interest

No conflict of interest to declare.

Supplementary material

None.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 166–173
DOI: 10.5603/demj.100867

ISSN 2451–4691, e-ISSN 2543–5957

INCREASED INCIDENCE OF HAEMOLYTIC ANAEMIA IN COVID-19 PANDEMIC TIME? A CROSS-SECTIONAL STUDY

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ABSTRACT

INTRODUCTION: After the global impact of the Coronavirus Disease 2019 (COVID-19) pandemic, which affects over 50 million individuals worldwide, the immune system has been reported hyperactivation and heightened autoantibody production. Post the COVID-19 pandemic, the diagnosis of hemolytic anemia has also exhibited a noteworthy escalation in emergency department admissions, capturing the attention of clinicians in this setting. Considering that autoimmune haemolytic anaemias are also classified under this group, the study investigated whether there was in fact a change in the incidence of haemolytic anaemia.

MATERIAL AND METHODS: The study included retrospective data from 591 patients admitted to the emergency department and diagnosed with anemia between September 2020 and September 2023. A retrospective review of patient records covered both pre- and post-diagnosis periods. The collected data comprised demographic information, laboratory values, primary diagnoses, and clinical outcomes. The classification resulted in three distinct groups: Chronic Anemia (CA), Anemia Due to Blood Loss (BLA), and Hemolytic Anemia (HA).

RESULTS: Between 2020 and 2023, the incidence of anemia notably decreased among patients in the CA group, whereas a significant increase in anemia incidence was observed among patients in the HA group over the same study period (p value < 0.05).

CONCLUSIONS: The study found that there was indeed an increase in the incidence of haemolytic anaemia. However with this, further detailed studies are needed to determine whether the rise in the incidence of hemolytic anemia during the COVID-19 pandemic is attributable to autoimmune disease.

KEYWORDS: incidence of anemia; hemolytic anemia; COVID-19; autoimmune diseases

Disaster Emerg Med J 2024; 9(3): 166–173

INTRODUCTION

Anaemia stands as the most prevalent haematological disorder, and the availability of comprehensive epidemiological and statistical data is hindered by divergent definitions. Nevertheless, the World Health Organization (WHO) provides the most reliable assessment of anaemia data. According to WHO, approximately 24.8% of the global population is affected by anaemia, with the highest prevalence observed among preschool children, pregnant women, and the elderly, in descending order [1].

Frequent encounters with patients presenting with anaemia in emergency departments underscore the significance of their thorough evaluation and

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Received: 26.05.2024 Accepted: 30.07.2024 Early publication date: 12.08.2024

management. Effectively addressing the aetiology, conducting further examinations, and initiating appropriate treatment in the emergency department play a crucial role in optimizing patient care for anaemia [2].

Patients with anaemia may present at the emergency department with symptoms directly attributable to anaemia, or they may manifest with asymptomatic or nonspecific complaints. Comprehensive data on the frequency of anaemia cases in the emergency department are currently limited [3].

Patients with anaemia admitted to emergency services may present with a variety of complaints, including weakness, fatigue, coldness, paleness, yellowing of the skin and eyes, chest pain, abdominal pain, and, in cases of acute blood loss, symptoms such as hypotension, tachycardia, and altered consciousness. Numerous tests essential for diagnosing anaemia are routinely utilized in emergency departments. However, for certain aetiological classes of anaemia, haematologists may require additional tests to be conducted to facilitate treatment planning [4].

Haemolytic anaemia is a condition characterized by the destruction of red blood cells. This can occur due to antibodies against red cell antigens or through non-immune-mediated breakdown of red cell membranes. When the antibodies are produced by the host, the resulting anaemia is termed autoimmune haemolytic anaemia (AIHA). The incidence of AIHA is approximately 1 in 100,000 people per year [5]. Haemolytic anaemia can be classified as secondary, resulting from an underlying cause, or primary, occurring as an independent phenomenon [6].

In haemolytic anaemias, there is a notable elevation in LDH values released into the circulation during erythrocyte destruction and haemolysis. Additionally, bilirubin levels increase indirectly as a result of haemolysis. Haptoglobin, an acute phase reactant that binds to free haemoglobin, plays a crucial role in the diagnosis of haemolytic anaemia; its serum values decrease when haemolysis occurs [7].

In the differential diagnosis of autoimmune haemolytic anaemia, Coombs tests include the direct antiglobulin test (DAT) and indirect antiglobulin test. A positive result in the DAT is indicative of autoimmune haemolytic anaemia [7, 8].

Due to the plethora of definitions and the focus on populations with high prevalence, such as the elderly, preschool children, and pregnant women, studies on anaemia in the literature are often concentrated in these groups. Recognizing that the limitation of epidemiological and statistical data on anaemia is associated with this concentration, the study was designed to investigate the incidence and demographic characteristics of anaemia patients admitted to the emergency department over 3 years.

MATERIAL AND METHODS

Study setting and participants

This study was designed by retrospectively reviewing the data of patients who presented to the tertiary-level emergency department in Konya, Turkey and received a preliminary diagnosis of anaemia.

Sample size estimation

Since the study was retrospective and it was possible to reach all the data, the sample size was not calculated and it was aimed to reach the whole population.

Patients groups

Anaemia patients presenting to the emergency department and receiving a diagnosis were classified into three groups: 1) The CA group, encompassing cases related to iron deficiency, vitamin deficiencies, chronic kidney failure, and chronic liver failure; 2) The BLA group, including gastrointestinal system bleeding, genitourinary system haemorrhages, bleeding due to gynaecological pathologies, irregular menstrual bleeding, and oesophageal variceal bleeding; 3) The HA group, involving erythrocyte deformities, erythrocyte membrane disorders, membrane enzyme defects, immune and autoimmune diseases, viral infections (Mycoplasma, EBV, HIV), and drug-induced anaemias. The study compared the rates of all three patient groups within the 2020-2023 date range.

Exclusions were made for individuals under the age of 18 and over the age of 65 (n: 689), pregnant patients (n: 112), those with acute blood loss due to trauma (n: 292), early post-operative patients (n: 42), patients diagnosed with malignancy (n: 194), patients using neoplastic drugs (n: 82), and those with missing data (n: 79). Following these exclusions, the study comprised 591 patients who presented to the emergency department between September 2020 and September 2023 and were diagnosed with anaemia. The patient flow chart is presented in Figure 1.

As is well known, this period also includes the COVID-19 pandemic. Although the prevalence of infected individuals is high, not all patients with anaemia underwent COVID-19 testing, and routine COVID-19 tests were not conducted on anaemic patients. The comparisons made in the study pertain to the incidence of anaemia following the post-COVID pandemic period.

Data collection, and statistical analyses

For each of the CA, BLA, and HA groups, an analysis of variance (ANOVA) test was conducted to compare Hb (Normal range: 13–17 g/dL), Htc (Normal range: 40–49 %), MCV (Normal range: 80–94 fL), MCH (Normal range: 27–35 pg), MCHC (Normal range: 32–35 g/dL), PLT (Normal range:150–450 x $10^3/\mu$L), LDH (Normal range: 135–214 U/L), and indirect bilirubin values. The homogeneity assumption was assessed using the Levene test, and it was determined that the homogeneity assumption was violated in all analyses (p value < 0.05). Given the violation of the homogeneity assumption in the ANOVA analysis, the Welch correction was applied due to a lack of significance in the Levene test ($p > 0.05$) and ANOVA test ($p > 0.05$), while the Welch test yielded significance ($p < 0.05$).

Descriptive statistics, including mean, standard deviation, standard error, and confidence intervals for the mean, were calculated.

Statistical Packages for the Social Sciences (SPSS) 18.0 Windows software package (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of the findings obtained in the study.

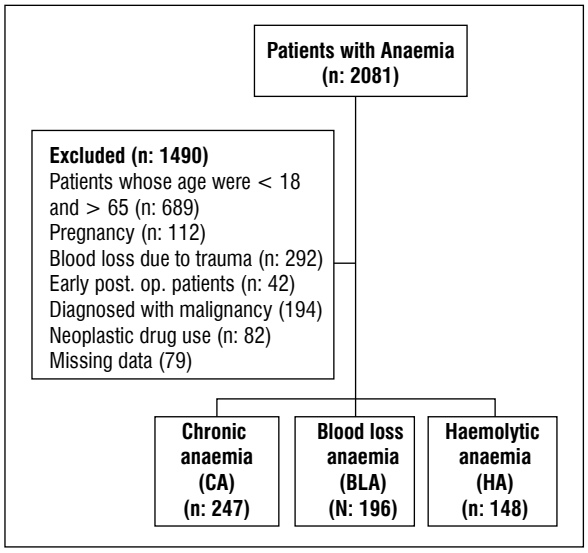

FIGURE 1. Diagram of inclusion and exclusion cases

RESULTS

The study comprised 591 patients, including 173 males and 418 females. A distribution analysis revealed that 44.3% (n: 262) of the patients fell within the 35–50 age range, 34.2% (n: 202) were over 50 years old, and 21.5% (n: 127) were under 35 years old (Tab. 1).

The comparative analysis of Hb, Htc, MCV, MCH, MCHC, PLT, LDH, and indirect bilirubin values among CA, BLA, and HA patients revealed significant differences (p value < 0.05). Descriptive statistics, including mean, standard deviation, standard error, and confidence intervals for the mean, are presented in Table 2.

Based on the results obtained from pairwise comparisons, it was observed that the BLA group exhibited lower, the CA group had intermediate, and the HA group demonstrated the highest Hb and Hct values. Furthermore, among the BLA, CA, and HA groups, a significant difference was identified in MCH and MCHC values (p value < 0.05). In the comparison of MCV values, it was found that the MCV values in the BLA and HA groups were significantly higher than the MCV values in the CA group (p value < 0.05). However, there was no significant

Table 1. Gender and age distribution of patients included in the study

		Frequency	Percent	Valid percent	Cumulative percent
Gender	Male	173	293	29.3	29.3
	Female	418	70.7	70.7	100.0
Age	35–50	262	44.3	44.3	44.3
	> 50	202	34.2	34.2	78.5
	< 35	127	21.5	21.5	100.0
Total		591	100.0	100.0	

Table 2. The comparative analysis of Hb, Htc, MCV, MCH, MCHC, and PLT values among chronic anaemia, blood loss anaemia and haemolytic anaemia patients

		Patients (n)	Mean	Standard Deviation	Standard Error	95% Confidence	
					Lower Bound	Upper Bound	
Hb	CA*	247	8.595	1.7475	0.1112	8.376	8.814
	BLA**	196	7.438	2.6109	0.1865	7.070	7.806
	HA***	148	11.189	2.1703	0.1784	10.836	11.541
	Total	591	8.861	2.6002	0.1070	8.651	9.071
Hct	CA	247	29.838	4.4692	0.2844	29.278	30.399
	BLA	196	27.041	9.1326	0.6523	25.754	28.327
	HA	148	38.547	5.2512	0.4316	37.694	39.400
	Total	591	31.091	7.9255	0.3260	30.451	31.732
MCV	CA	247	72.544	9.6804	0.6159	71.331	73.757
	BLA	196	82.331	13.985	0.9989	80.361	84.301
	HA	148	88.369	16.850	1.3851	85.632	91.106
	Total	591	79.699	14.749	0.6067	78.508	80.891
MCH	CA	247	22.145	5.5183	0.3511	21.453	22.836
	BLA	196	29.598	6.2080	0.4434	28.723	30.472
	HA	148	38.037	8.0400	0.6609	36.731	39.343
	Total	591	28.443	9.5154	0.3914	27.674	29.212
MCHC	CA	247	28.532	2.5674	0.1634	28.211	28.854
	BLA	196	34.514	3.3047	0.2360	34.049	34.980
	HA	148	41.647	7.0546	0.5799	40.501	42.793
	Total	591	33.810	7.1509	0.2941	33.133	34.288
PLT	CA	247	310.00	94.835	6.034	29811	321.89
	BLA	196	288.94	79.957	5.711	277.68	300.20
	HA	148	284.01	65.151	5.355	2273.42	294.59
	Total	591	296.51	83.993	3.455	289.72	303.29

*Chronic anaemia, **Blood loss anaemia, ***Haemolytic anaemia

difference between the BLA and HA groups in terms of MCV values (p value $>$ 0.05). While no significant difference was observed in PLT values between BLA and CA patients (p $>$ 0.05), it was noted that PLT values were lower in HA group patients (Tab. 2).

Patients in the BLA, CA, and HA) groups had a 4.6%, 6.1%, and 100% probability of elevated LDH levels, respectively. According to the results of the ratio test, the difference in the probability of high LDH was found to be statistically significant for all three groups (p value $<$ 0.05). This difference was further examined through pairwise comparisons for a detailed analysis.

In this context, no significant difference was identified in the probability of LDH and indirect bilirubin elevation between BLA and CA groups, and this probability was observed to be low. However, the probability of high LDH and indirect bilirubin in HA group patients was 1, indicating a complete likelihood, and this probability was found to be significantly different from other diagnoses (Tab. 2, 3).

The rates of CA, BLA, and HA patients in the years 2020–2023 are presented in Table 3. A proportion test was conducted to assess whether the rates of patients in all three groups exhibited significant changes over the years. Holm correction was applied in pairwise comparisons for a comprehensive analysis.

According to the results of the proportion test, there was a significant difference in the rates of CA patients by year (p value $<$ 0.05). The difference in the rates of HA patients by year was found to be significant (p value $<$ 0.05). Furthermore, there was

Table 3. The crosstabulation of chronic anaemia, blood loss anaemia and haemolytic anaemia patients in the years 2020–2023

Date		Diagnosis Code			
		CA*	BLA**	HA***	Total
2020	Count	76	53	28	157
	% within date	48.4%	33.8%	17.8%	100.0%
	% within diagnosis code	30.8%	27.0%	18,9%	26.6%
2021	Count	58	42	15	115
	% within date	50.4%	36.5%	13.0%	100.0%
	% within diagnosis code	23.5%	21.4%	10.1%	19,5%
2022	Count	49	48	55	152
	% within date	32.2%	31.6%	36.2%	100.0%
	% within diagnosis code	19.8%	24.5%	37.2%	25.7%
2023	Count	64	53	50	167
	% within date	38.3%	31.7%	29.9%	100.0%
	% within diagnosis code	25.9%	27.0%	33.8%	28.3%
Total	Count	247	196	148	591
	% within date	41.8%	33.2%	100.0%	100.0%
	%within diagnosis code	100.0%	100.0%	100.0%	100.0%

*Chronic anaemia, **Blood Loss anaemia, ***Haemolytic anaemia

no significant change in BLA patient rates over the 2020–2023 period (p value $>$ 0.05).

In summary, over the three years from 2020 to 2023, a decrease was observed in the proportion of CA patients, while the rate of HA patients increased.

DISCUSSION

Patients with anaemia frequently present to the emergency department, and the evaluation and management of anaemia constitute a crucial aspect of emergency medical care. The epidemiology and statistical data related to anaemia face limitations due to the broad and diverse definitions and aetiologies associated with this condition [3]. Nevertheless, existing studies in the literature typically focus on populations where the prevalence of anaemia is widespread. Notably, in elderly patients, individuals with chronic kidney failure, chronic liver failure, additional malignancies, and those using medications for chronic diseases, the incidence of anaemia tends to increase [9]. The higher prevalence of anaemia in men compared to women could be attributed to the WHO definition, where anaemia is defined as haemoglobin levels below 13 g/dl for men and below 12 g/dl for women, as well as inherent physiological differences between genders [1]. Additionally, in pregnant women, the incidence of anaemia tends to increase due to gestational physiology, heightened metabolism, nutritional deficiencies, and lower socioeconomic status [2, 10]. Anaemia impacts 20% of children in the United States [11]. Similar to adults, anaemia in preschool children can arise from factors such as decreased production or destruction of red blood cells. Iron deficiency anaemia is a prevalent cause of anaemia in children. Additionally, hereditary anaemias, such as sickle cell anaemia and thalassemia, are common among children [12]. Acute blood loss secondary to trauma stands out as one of the most frequent causes of anaemia due to acute blood loss observed in the emergency department [13].

The present study aimed to investigate the incidence and demographic characteristics of anaemia, a condition less frequently encountered in emergency department admissions. To achieve this, deliberately excluded were populations with a higher incidence of anaemia, such as individuals over 65 years of age, those under 18 years of age, pregnant patients, individuals diagnosed with malignancy, patients using neoplastic drugs, and those diagnosed with anaemia secondary to trauma.

The patients included in the present study were categorized into three major groups: CA, BLA, and HA. Utilizing clinical and laboratory values from retrospective patient data as a basis, patients were classified based on Hb, Htc, MCV, MCH, MCHC, LDH, and indirect bilirubin levels.

Particularly in the HA group, there was a statistically significant difference in LDH and indirect bilirubin levels compared to the other two groups. This once again reaffirmed the conclusion that LDH and indirect bilirubin are crucial factors in determining the diagnosis of haemolytic anaemia. The values of LDH and Indirect Bilirubin were identified as diagnostically and predictively important for haemolytic anaemia.

In the CA group, consultation with the General Internal Medicine branch was sought by the emergency clinician to determine the chronic disease and aetiology of anaemia. For patients in the BLA group, the emergency clinician assessed the acute or chronic status and initiated blood transfusion and volume replacement, considering vital signs (hypotension, tachycardia), state of consciousness, and Haemoglobin values ($<$ 8g/dL) in 67 cases. All patients in the Anaemia Due to Blood Loss (BLA) group who were initially intervened in the emergency department underwent further evaluation. The focus of bleeding was identified, and patients were subsequently admitted to specialized clinics for additional examination and treatment. Specifically, 133 patients were referred to Gastroenterology-General Surgery for issues related to gastrointestinal bleeding and oesophageal variceal bleeding, while 63 patients were directed to Gynecology-Urology for myometrial and genitourinary haemorrhage. Due to the absence of routine tests such as haptoglobin, Coombs test, and serum protein electrophoresis in the emergency clinic where the study was conducted, cases with elevated LDH and indirect bilirubin levels in the HA group were identified. The emergency clinician was guided to consider haemolytic anaemia as the cause of anaemia in this group. Subsequently, consultation with haematology was sought to distinguish the aetiology of haemolytic anaemia, and these patients were hospitalized for further examination and treatment.

Given the exclusion of patients aged $>$ 65 and $<$ 18 from this study, the age range with the highest incidence of anaemia was identified as being between 35–50 years. The higher number of patients in this age range can be attributed to the presence of a significant female population within the childbearing age group. This explains why the number of female patients (n: 418) is higher than the number of male patients (n: 173). Consequently, it is reasonable to assert that genitourinary and gynaecological pathologies, characterized by conditions such as menorrhagia, metrorrhagia, ectopic pregnancy, and irregular menstruation, play a significant role in causing anaemia in women of childbearing age, excluding elderly and paediatric patients [14].

The substantial rise in the rate of Haemolytic Anaemia (HA) patients over the three years from August 2020 to January 2024 has prompted a reevaluation of the aetiology of haemolytic anaemia. Haemolytic anaemias can be categorized into two main groups: 1) hereditary causes, including erythrocyte deformities, membrane disorders, enzyme deficiencies, *etc*., and 2) acquired causes, such as immune reactions, autoimmune disorders, viral infections, mycoplasma, HIV, drug-induced reactions, *etc.* [15, 16].

The present study observed that all patients admitted to haematology with the diagnosis of haemolytic anaemia were newly diagnosed. Given that the age range with the highest number of patients is between 35–50, it would have been expected for patients to be diagnosed with hereditary haemolytic anaemia much earlier in life. Consequently, the increased incidence of haemolytic anaemia in this context is likely attributed to acquired haemolytic anaemias [17].

Taking into consideration the global impact of the COVID-19 pandemic between 2020–2023, it is evident from numerous cases and case series studies in the literature that there has been an increase in autoimmune diseases associated with COVID-19 [18–20]. Remarkably, among the autoimmune diseases that have seen an uptick after the pandemic, there is a notable increase in case series related to haemolytic anaemia, drawing significant attention in the medical literature [21, 22].

The principal limitation of the study lies in the fact that Emergency Clinicians were unable to ascertain the aetiology of haemolytic anaemia in patients diagnosed with this condition. This was primarily due to the absence of routine tests, such as haptoglobin, reticulocyte count, Coombs test, and serum protein electrophoresis, which are not typically conducted in emergency departments.

CONCLUSIONS

The incidence of patients diagnosed with haemolytic anaemia in the emergency department where the study was conducted increased between 2020 and 2023, corresponding to the COVID-19 pandemic period. There are studies in the literature indicating that the COVID-19 pandemic has led to an increase in autoimmune diseases. Further detailed studies are needed to determine whether the rise in the incidence of haemolytic anaemia during the COVID-19 pandemic is attributable to autoimmune disease.

Article information and declarations

Data availability statement

Workers have access to the data, provided that it is not disclosed to third parties.

Ethics statement

Ethics approval was obtained from the local ethics committee (date:04.01.2024, number: 01-40).

Author contributions

Demet Acar: conception, design, wrote the paper, supervision; Nazlı Kenan Karakuş: data collection and processing; Fatih Cemal Tekin: conception, design, wrote the paper, supervision.

Funding

No support was received from any institution or organisation.

Acknowledgments

None.

Conflict of interest

No conflict of interest between the authors.

Supplementary material

None.

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VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 174–185
DOI: 10.5603/demj.101945

ISSN 2451–4691, e-ISSN 2543–5957

MEDICAL SIMULATION CENTER ACTIVITY AND KNOWLEDGE TRANSFER DURING THE COVID-19 PANDEMIC

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ABSTRACT

INTRODUCTION: The Medical Simulation Center (MSC) of Poznan University of Medical Sciences was established in 2010 as the educational university center. In 2020, the COVID-19 pandemic faced new challenges, which forced multi-pronged new activities of this unit to increase the patient's safety in the region. The purpose of this study was to assess the multi-profile activity performed in the Medical Simulation Center during the COVID-19 pandemic.

MATERIAL AND METHODS: Authors except the primary educational activity realized in epidemiological conditions from March 2020 to March 2022, identified 6 new areas and projects that were prepared on the initiative of the MSC, using its premises, technical, and know-how resources.

RESULTS: In the results, authors quantify the redistributed equipment resources and the completed training and normal education activity adapted to epidemiological restrictions. Basic courses and vaccination courses resulted in the creation of a significant group of volunteers prepared to work in destructive consequences of the pandemic COVID-19 including 24 months of activity of point of screening and testing. In Extracorporeal Membrane Oxygenation (ECMO) training in the cognitive, behavioral, technical, and knowledge assessment significant improvement was observed. Moreover, the upgraded trainers' skills provoke to prepare the complex nursing procedures for ECMO patients with COVID-19.

CONCLUSIONS: The multifaceted activity of the MSC confirms the great potential of this type of training unit based on medical simulation techniques as an educational tool, especially in the face of the real threat of a global epidemiological crisis. MSC can be an education center creating new procedures, standards of care, and best practices.

KEYWORDS: coronavirus; COVID-19; medical simulation; Medical Simulation Center

Disaster Emerg Med J 2024; 9(3): 174–185

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Recieved: 05.08. 2024; Accepted: 13.08.2024; Early publication date: 16.09.2024

INTRODUCTION

The Medical Simulation Center (MSC) at Poznan University of Medical Sciences was established in 2010, the originally occupied area was 90 m^2, and 2 simulation rooms with a control room and a debriefing room. Since 2018, the area has been over 2700 m^2, which includes, among an ambulance simulator, a delivery room, an emergency room, an ICU, an operating room, low and high-fidelity nursing rooms, technical rooms, rooms for classes with simulated patients, and Objective Structured Clinical Examination — OSCE exams. Equipment and instructor training are financed by EU support under the Operational Project Knowledge Education Development, the main objective of which is to support the medical, nursing, and midwifery faculties.

The primary educational tasks are carried out in low-intermediate and high-fidelity classrooms. A novelty is classes with the participation of Standardized Patients in specially designed rooms. "Patients" have both acting skills, developed under the supervision of the director, and the ability to evaluate the student's conduct and provide him with feedback, which has a huge impact on the proper course of the education process and allows for simultaneous teaching of both appropriate communication (taking an interview, educating the patient, providing unfavorable information, *etc.*) and a wide range of practical skills (physical examination, selected medical procedures) [1–3].

In 2019 in MSC to reach high standards of patient care, the first of its kind in Poland, the National Education Centre for Artificial Life Support (NEC-ALS) was created. The role of the Center is to test and promote novel or commonly used procedures as well as to develop staff skills in the management of patients needing ECMO. This event preceded the COVID-19 pandemic, which the whole world had to face since the beginning of 2020 [4, 5].

The rapid widespread of the SARS-CoV-2 virus in early 2020 caused global chaos. In the initial period, a lack of knowledge of epidemiology and viral contamination, as well as no availability of either causal treatment or preventive vaccination, resulted in a global lockdown and preparing global crisis [6–9].

Overnight, new multi-track activities appeared in front of the MSC, aimed at trying to continue educational activities, as well as other forms of activities that could become socially useful in a deep epidemiological crisis. The multi-profile activities of the MSC during the COVID-19 pandemic provided the opportunity to use the unit's resources to conduct several trainings and initiatives [10, 11]. Their implementation had a significant share in the activities of units conducting activities related to direct contact with potentially ill people, and in the subsequent phases of the pandemic, the actions taken led to the expansion of access to vaccinations [11–13].

MATERIAL AND METHODS

The main aim of this study is to present the retrospective report of multi-profile activities of the MSC during the COVID-19 pandemic.

The authors collected and summarized all MSC activities during the COVID-19 pandemic between March 2020 and March 2022. Seven areas of activity were identified and for every area, the methodology was individually defined and presented in a chronological timeline:

1. Medical equipment;
2. Basic medical training;
3. Extracorporeal techniques medical training;
4. Nursing Standard Operating Procedure applicable to ECMO patients with COVID-19;
5. Point of screening and testing (POST);
6. Vaccination training;
7. University education activity.

RESULTS

Medical equipment

The medical equipment was relocated during the first wave in February 2020 from the Medical Simulation Center PUMS for the clinical area. All equipment was inventoried, moreover the final location was identified. In the first wave of the pandemic from 20th March 2020, in accordance with the regulation of the Ministry of Health, a state of epidemic was in force in Poland. During the first 48 hours of that state, a technical review was carried out to confirm the full usefulness of the equipment available for clinical use in the possession of MSC. In the next 2 days collected in Table 1 equipment was delivered to the Multiprofile Clinical Hospital USK PUMS. In April for the next 3 months due to the parallel increase in demand for the use of extracorporeal circulation techniques, a decision was made to immediately support units with ECMO devices. In response to the needs of society, the device was handed over via the Air Ambulance Service to the Intensive Care Unit at the University Clinical Hospital in Opole to provide equipment support (Tab. 1).

Table 1. Equipment delivered to the Multiprofile Clinical Hospital USK PUMS in the first wave COVID-19 pandemic

Type/name of equipment	Amount of equipment	Previous use of equipment in MSC	Using equipment to save citizens' health and lives	Information on people it can help
CARESCAPE R860 stationary ventilator with accessories	3	Oxygen therapies with advanced patient simulators	Yes	Due to the growing risk of patient volume, the equipment was intended to secure the increased number of patients and procedures at the Department of Anesthesiology and Intensive Care
Cerdiomonitor GE B40	3	Learning how to connect electrodes to the patient and simulators	Yes	
Volumetric Infusion Pump	22	Therapies with the use of infusion pumps	Yes	
Syringe Infusion Pump	14	Therapies with the use of infusion pumps	Yes	
Ventilator System Kit	50	Single use equipment	Yes	
Cardiohelp ECMO console	1	Artificial Life Support with ECMO Course	Yes	Air Ambulance Service (HEMS) to the University Clinical Hospital in Opole for Intensive Care Unit support

Table 2. Equipment was delivered to the Temporary Hospital of the University Clinical Hospital of the PUMS in the first wave COVID-19 pandemic

Type/name of equipment	Amount of equipment	Previous use of equipment in CSM	Using equipment to save citizens' health and lives	Information on people it can help
Defibrillator Lifepak 15	2	Advanced Life Support procedures	Yes	Basic medical activity for patients of the temporary hospital
Anesthesia trolleys	10	Storage of medical disposable equipment	Yes	

In the middle of 2020 in the first wave of the pandemic in connection with the commencement of the creation of the Temporary Hospital, which operated within the structures of the University Clinical Hospital of the PUMS, the following equipment from Table 2 was donated.

Basic medical training

An innovative and adaptive training plan for students of various medical faculties was designed for all years of study — medicine, nursing, and midwifery [11]. The offer was addressed to volunteers who can support the work at the newly created PUMS Temporary Hospital. In the first wave of the pandemic, only volunteers with a negative COVID-19 test were allowed to attend classes, and vaccinated participants were included in subsequent waves. In the beginning for staff and students' safety medical and technical staff prepared workshops for every member: proper hand disinfection, full and partial PPE dressing, and undressing techniques. Moreover, the easy cartoon legend was prepared for every educational station.

Educational training for medical students was based on two pillars. The first one was an 8-hour module (e-learning), which included gaining knowledge in the field of anatomy and physiology, principles of oxygen therapy and blood gas assessment, principles of sedation, maintaining airway patency, and the basics of theoretical ventilation and personal protective equipment. The practical part was designed and carried out at the MSC under a strict sanitary regime during a two-day training course — 22 hours — Table 3. Each student and the teacher were required to wear protective masks, in addition, the group was divided into non-rotating parts, the number of which did not exceed 4 people.

For nursing and midwifery students, a 1-day 7-hour module was prepared in the field of recognizing life-threatening conditions, the principles

Table 3. Basic course program for physician students		
Number of hours	COURSE PROGRAM	SIMULATION TECHNIQUES
DAY 1		
8	Theoretical background — e-learning	
DAY 2		
2	ALS	Low/high fidelity
1	Artery, venous cannulation	Low fidelity
1	Imagination	Hybrid simulation
1	Sedation	Workshops
1	Oxygen therapy	Workshops
1	Airways — Supraglottic devices, Intubation	Low fidelity
1	Personal Protective Equipment	High fidelity
2	Transportation	High fidelity
2	Ventilation	High fidelity
DAY 3		
1	Respirators — devices	Low fidelity
3	Respiratory therapy	Middle fidelity
1	Respiratory toilet	High fidelity
1	Monitoring	High fidelity
4	Mechanical ventilation	High fidelity

Table 4. Basic course program for nurse and midwife students		
Number of hours	COURSE PROGRAM	SIMULATION TECHNIQUES
DAY 1		
1	Personal Protective Equipment	High fidelity
2	Airways and respiratory efficiency	Middle fidelity
1	Respiratory toilet	High fidelity
1	Oxygen therapy	High fidelity
2	Mechanical ventilation — Nursing management	High fidelity

Table 5. Total number of students who participated in MSC training, number of active volunteers in temporary hospital, and percentage rate

Students	Total	Active volunteers in TH	% rate
Medicine	293	195	66.5 %
Nurse	45	37	82.2 %
Midwives	13	10	76.9 %

of using modern methods of oxygen therapy, or monitoring the condition of a patient treated with oxygen — Table 4.

293 medical students, 45 nurses, and 13 midwives responded to the training offer, which ensured the creation of a buffer of people with dedicated training to work in the Temporary Hospital (TH) PUMS. No additional results are available except the recruitment rate to that hospital presented in Table 5.

Extracorporeal techniques medical training

In years 2020–2022, 23 approved and endorsed by Extracorporeal Life Support Organization (ELSO)

courses of "Artificial Life Support with ECMO" were organized. The project was awarded in 2018 funding from a POWER competitive national grant (POWR.05.04.00-IP.05-00-006/18) by the Polish Ministry of Health for a total of 2.750.000 USD (PLN 10.974.708.60).

Physicians participated in the three-day high-fidelity simulation-based training that was adapted to abide by the social distancing norms of the COVID-19 pandemic — one course for 12 participants per month. The course was provided in created in 2019 "Center of Artificial Life Support and Patient Safety" in the Medical Simulation Center at the PUMS. The postgraduate education was formulated in a 3-day course, where 50% of educational hours were implemented in the form of workshops and classes in simulated conditions — 25 didactic hours spread over three days during a one-weekend meeting (one month apart). All course details were presented by Ziemak et al. [4] and Puslecki et al. [5]. The relationship number of students for participants was changed during the COVID-19 pandemic: there were a maximum 4 people per room and 1 instructor in the theoretical part and 2 instructors (both with content expertise) for every 2 participants in ECMO technical skills and 2 (one with formal debriefing training and other with content expertise) for 4 during simulations in separated rooms. It was possible thanks to simultaneous simulations and debriefings in three 4-person subgroups with innovative audio-visual solutions.

Knowledge as well as crucial cognitive, behavioral, and technical aspects (on a 5-point Likert scale) of management on ECMO were assessed before and after course completion.

The group of 276 physicians participated in 23 editions of the ECMO course in the period March 2020 — March 2022 — specialists and residents in anesthesiology and intensive care, cardiology, cardiac surgery, thoracic surgery, vascular surgery, transplantology, and emergency medicine. The recruitment was voluntary and open to all physicians in Poland, and after accepting the application, each candidate completed a study participation form and written consent. In total project was finalized in 2023 after 34 courses and 405 participants.

There were 276 participants (60% men) predominantly in the age of 30–40 years. The majority of them (65%) were anesthesiologists or intensivists with more than 5-year clinical experience, but 58% had no previous ECMO experience. There was significant improvement after the course in all cognitive, behavioral, and technical self-assessments. Among aspects of management with ECMO that all increased significantly following the course, the most pronounced was related to the technical one (from approximately 1.0 to more than 4.0 points). Knowledge scores significantly increased post-course from 11.6 ± SD to 13 ± SD (out of 15 points). The statistical significance of the results is comparable with previously presented publications by Puslecki et al. and Ziemak et al. [4, 5]. Detailed results for that group are presented in Figure 1.

Nursing Standard Operating Procedure applicable to ECMO patients with COVID-19

A high-fidelity translational simulation scenario was developed to create the SOP for nursing management with COVID-19 patients supported with ECMO. It included practicing safe and proper personal protective equipment (PPE) donning and doffing during work organization, ECMO cannulation and ECMO-related procedures, and routine daily nursing care and management of patients on ECMO over nine hours. Supplementary constructive debriefing with the assistance of international expert consultation and narrative literature research were performed. All details were presented by Puslecki et al. [14].

Results of high-fidelity ECMO patient scenarios performed in MSC were collected in three parts — proposal of nursing standardized operating procedures. They provide work organization, workload references, competencies, and infrastructural conditions. Additionally, the cannulation equipment checklist proposal and daily routine nursing algorithm with other procedures during extracorporeal support were created. Practical results were presented in the publication by Puslecki et al. [14] and a dedicated chapter in the Polish language book dedicated to Nursing Management [15].

Point of screening and testing (POST)

MSC was the initiator and creator of the Poznan University of Medical Sciences (PUMS) COVID-19 drive-through testing point. Initially, a small drive-through site extended to a large modern laboratory point of screening and testing (POST) system for maximal high volume of patients. PUMS POST activity lasted 24 months and developed significantly. The detailed organization and reorganization of POST PUMS with point model efficiency during all COVID-19 waves were presented by Ziemak et al. [16].

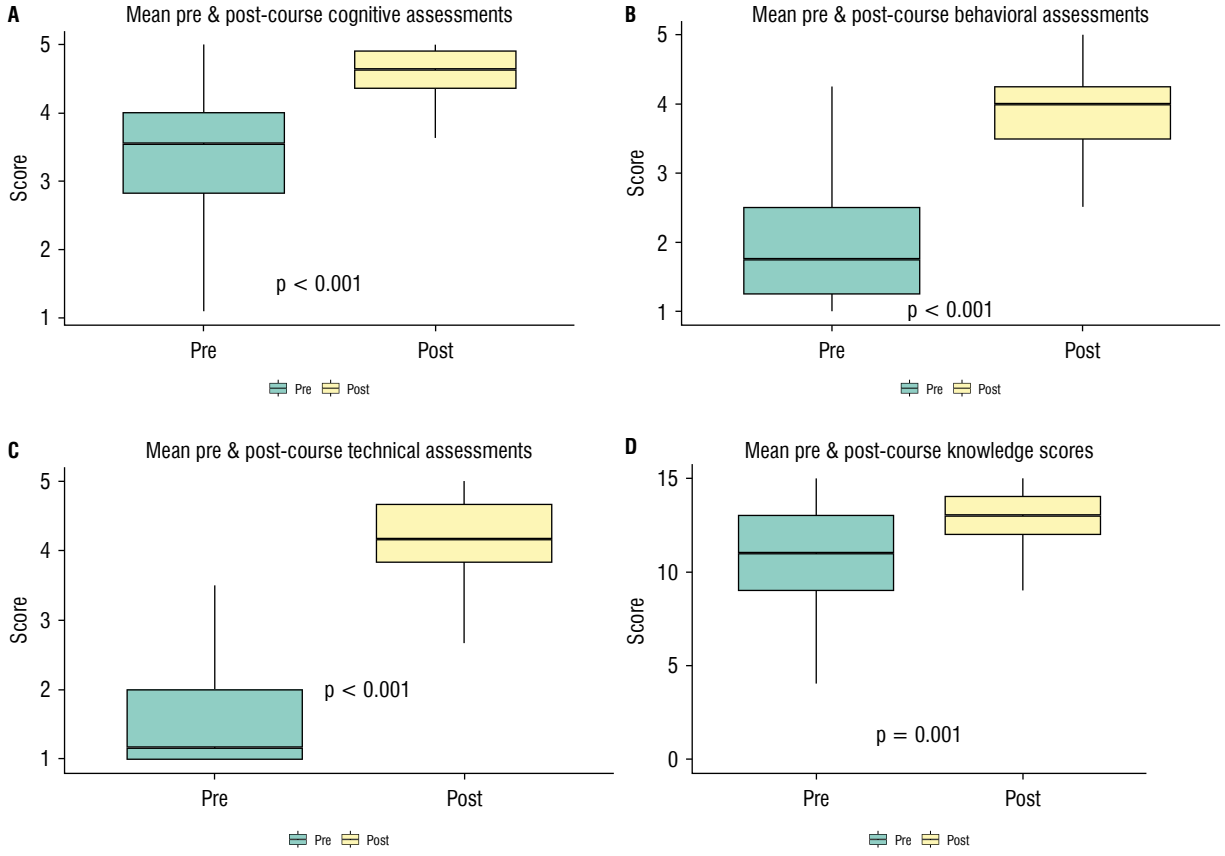

FIGURE 1. Detailed results for pre and post-course cognitive (A), behavioral (B), technical (C), and knowledge (D) assessment

MSC was the initiator and creator of Poznan University of Medical Sciences (PUMS) COVID-19 drive-through testing point for 3.5 million inhabitants in the Greater Poland Region during the 1st through 4th coronavirus pandemic waves. Development of the POST model phases and assessment of simulation education effectiveness developed for 103 volunteers including authorship tele-screening and qualification center were presented in the publication [16]. The main results were reported in a decreased median time of PPE wear and statistically significant improvement in the median time of swab collection and the total number of swabs in one-hour activity between waves.

Vaccination training

In response to the needs of the public and the plan to increase the vaccination rate, the Medical Centre for Postgraduate Education has taken the initiative to Polish Medical Universities to organize training for physiotherapists, pharmacists, and laboratory diagnosticians who will be able to obtain qualifications to carry out preventive vaccinations against COVID-19. The theoretical module covered topics related to the e-referral system, vaccination qualification, and the pre-vaccination screening interview questionnaire. The Medical Simulation Centre of PUMS undertook the organization of one of the largest training courses for the above-mentioned medical professions. The original training project assumed two required modules: a part related to the management of patients in life-threatening conditions and a module related to the practical side of preparing various types of vaccines and administering them to the patient through learning on specially prepared trainers — Table 6.

To ensure the quality, the trainers conducted training in subgroups of up to 12 people. The intensity of the classes required full coordination of the technical staff, who, in addition to replenishing the stations with disposable medical equipment, created simulating vaccines on an ongoing basis and ensured the uninterrupted operation of the injection trainers. The wear and tear of the equipment, combined with the difficult availability of interchangeable elements of the trainers, forced the development of modern remedial methods, which consisted of original casts of tissues simulating hu-

Table 6. Vaccination training program and prepared equipment	
COVID-19 vaccination course	
Preparation of the vaccine and intramuscular injection — 2 hours	Rules for providing first aid to patients undergoing COVID-19 vaccination — 2h
Equipment	
Trainer for injections Simulated vaccine solution A set of disposable materials: insulin syringes, 21G, 5 mL, and 10 mL 0.9% NaCl needles, alcohol swabs to disinfect the vial and each injection site, dry gauze pads to protect the injection site, injection patches, gloves, non-woven apron, kidney bowl, tray, a rigid container for medical sharps, medical waste bin, bins for segregating other waste (paper, plastic, mixed waste)	BLS Trainer AED Training Defibrillator Telephone Self-expanding bag Pocket mask Pulse Oximeter Epipen Adrenaline Training Syringes A set of consumable disposable materials such as gloves, masks, and disinfectant

FIGURE 2. Stations and trainers at MCS for vaccination training

man tissues. Their creation was possible thanks to the use of special silicones for castings with dedicated hardness and chemical properties — Figure 2.

In the first days after the launch of the courses, the readiness to carry out 126 courses was reported, finally reaching the number of trained people: 1785 people, of which 53% were pharmacists, 40% physiotherapists, and 7% laboratory diagnosticians.

University education activity

The authors assessed how the COVID-19 pandemic affected the organization of academic classes, what steps were taken to reduce the epidemiological threat, and how classes at the MSC were continued. The decision to completely suspend classes at the Medical Simulation Center took place on 12.03.2020 and, in accordance with the Regulation of the Minister of Health of the Polish Republic, the university's activities had to be limited until May 24. The lack of developed response schemes forced the shift of classes from standard mode to remote tools such as Teams or Moodle. As part of e-learning in teaching basic activities with the use of medical equipment, instructional videos were recorded for paramedics and nurses, used in learning specific subjects such as basic and advanced life support.

MSC staff during the first 3 days of onsite staff activity at MSC, patient simulators, trainers, and audio-video systems were adequately prepared for downtime, the length of which was not predetermined. During their remote work, simulation technicians were tasked with cataloging the Center's equipment, which trainers used to evaluate during their classes. In addition, workstation instructions were created, such as an instruction manual for the audio-video system workstation or instructions for creating simulation scenarios in one of several dedicated programs. The employees also took care of introducing dozens of simulation scenarios into the database, which were periodically created based on the work of academic teachers. Their programming to the two leading systems in the unit allowed us to

expand the case database to 320 ready-made automatic simulation scenarios.

Since June 2020, there has been a gradual unfreezing and classes began to return to face-to-face classes, including in the MSC and only to a minimal extent in teaching PUMS Clinical Hospitals. To ensure the safety of the organization of classes at the MSC, several systemic tasks were undertaken to maximize the safety of the activities carried out.

Starting with the employees of the unit – simulation techniques: two absolutely non-interchangeable shifts were created (morning and afternoon shifts). Common employee rooms were abolished, and each technician was given a separate work room to minimize common contact. The functioning of social rooms has been maintained, but a limit on the presence of only one employee has been introduced. In addition, the Medical University provided all employees with masks with a filter (FFP2, FFP3), which were to increase the safety of employees.

Student groups were introduced only in the regime of exercise category C (*i.e.* 6 students in the exercise subgroup). There was no rotation between group members, so it was not possible to make up for individual classes with another subgroup. Limitations in the functioning of teaching in clinical hospitals have increased the importance of the simulation environment, which has been adapted to conduct activities such as diploma examinations (Objective Structured Clinical Examination — OSCE). In 2020, the first standardized OSCE exams were held for nursing and midwifery faculties, which were unable to perform all the required procedures in contact with a patient in a hospital. Exams for 250 students were conducted in a repeatable, absolutely objective manner and with a full sanitary regime.

Classes with simulated patients were suspended until the end of the 2020/2021 academic year and then continued with their remote participation. Ultimately, contact classes with simulated patients returned in 2021 and took place under the sanitary regime.

DISCUSSION

The Medical Simulation Centre, as a unit where simulation classes for students are conducted using low, intermediate, and high-fidelity methods, is equipped with several pieces of medical equipment, which, in addition to its didactic value, has a therapeutic value – it is a full-fledged medical device adapted to work

FIGURE 3. Equipment of MCS prepared for University Clinical Hospital PUMS

with patients. In the first phase of the pandemic, in response to social uncertainty and several questions arising on the subject of the appropriate preparation of infrastructure resources to fight COVID-19, a decision was made to provide priority and direct transfer of medical devices to the University Clinical Hospitals in Poznan and Opole and the Temporary Hospital PUMS – Figure 3. The hospitals also received several disposable materials, which in the first days of operation were used as protection for the start-up of the equipment (including disposable sets for ventilators or sets for infusion fluids). Each piece of equipment was surface disinfected with an alcohol-based agent before returning to the MSC: Ethanol with concentrations ranging from 62% to 80% with exposure ≥ 15 s. Isopropanol 60–70% exposed on surfaces for at least 15 s [17]. Upon return to the MSC, equipment was quarantined for 7 days in an isolated room. Then it was again disinfected with an alcohol-based agent and a dedicated Aerodesin preparation (MediLab, Bialystok, Poland). After such preparation, the equipment was put again into use at MSC.

The PUMS Temporary Hospital (TH) was designed in the halls of the Poznan International Fair (MTP). In the first wave initially, 4 wards, every with 30 beds were launched, and they reached their maximum capacity in 8 wards, every with 30 beds, including the Intensive Care Unit. The urgent need to recruit employees for the Temporary Hospital accelerated the educational process at MCS, specially dedicated training for volunteer medical students. The training organized at the MSC was conducted using low, intermediate, and high-fidelity methods [11]. The cre-

FIGURE 4. High-fidelity training in full PPE

ation of a comprehensive course program allowed the participants to familiarize themselves with the full spectrum of duties to which they were to be delegated. The low-fidelity simulation was used to carry out technical procedures such as airway protection, intubation, and venous cannulation. Intermediate-fidelity simulation was based on simulators for transport exercises, and high-fidelity simulation methods were adapted for imaging and sedation exercises. In the initial phase, the trainers were recruited from medical professions, representing departments that had suspended the admission of patients during the pandemic lockdown. In the first place, qualified simulation trainers who had completed a 2-day PUMS Simulation Facilitator Course in previous years were used. After the launch of the TH, the medical staff delegated to work in this unit in the breaks between shifts were also included in the education sessions of volunteers.

Personal protective equipment necessary for full protection, reflecting the highest fidelity and difficult conditions of working with the patient, was provided for each student, which allowed to minimize the number of emergencies in later functioning during on-call duty — Figure 4. Practical improvement of skills and their transfer to the educational level brought measurable benefits related to the shortening of on-the-job training and increased awareness of the correct conduct in contact with an infected patient in a life-threatening condition. The training provided an increase in practical knowledge through clinical simulations using high-fidelity simulation tools. Patient simulators and trainers were tailored to the training needs and patients in different clinical conditions. Make-up and costumes adapted to individual cases were prepared, which increased the realism of the activities carried out. Students of the Faculty of Health Sciences, nurses, and midwives, were trained in recognizing life-threatening conditions, the principles of using modern oxygen therapy methods, or monitoring the condition of patients treated with oxygen. The conditions of the MCS and specially prepared equipment allowed for the implementation of all procedures necessary to practice, including proper communication, the care of the endotracheal and tracheotomy tubes, preparations for the implementation of invasive mechanical ventilation, including the performance of the device test [11].

The results of the ECMO course confirmed that simulation as an educational approach is invaluable not only in training and testing of novel or commonly used procedures, and skills upgrading but also in practicing very rare cases. According to information from ELSO in 2020 and 2021, the present study center was the only one in the world, despite the COVID-19 pandemic, doing courses in the stationary model. The implementation of the education program during the COVID-19 pandemic reached the whole country for ECMO centers and teams including mobile ones with valuable contributions to the development of highly qualified personnel and filling the gap in the field of extracorporeal techniques in Poland. 15 of the participants represented the national HEMS which, with the weak specialist transport systems from ECMO, created a system of air transportation for patients with ECMO support [4, 5].

Managing a patient with COVID-19 patients requiring ECMO support provokes the nonnatural changes in critical care. That situation shifted the burden of care and immediate intervention in crises to the nursing staff working in the contaminated zones of the ICU and required additional multidisciplinary staff with expertise in managing ECMO. The developing pandemic forced modifying common standards related to the use of PPE, and the increased patient workload. Optimization, maintenance, and adherence to isolation specific to

COVID-19 were necessary to reduce the risk of transmission of infection to the highly specialized ECMO team. The creation of SOPs in this area is one of the most important achievements of the MSC with a global reach, confirmed by numerous worldwide downloads of the published manuscript [14,15].

The drive-through POST system at PUMS, which operated as a unified and self-sufficient point was a pioneering solution in Poland. Using MSC resources, including simulation trainers and simulation techniques, allowed the preparation of the first team of employees of the point as a response to epidemiological demand. Presented in publication [16] POST model can be implemented worldwide in future epidemiological threats.

Since the beginning of 2021, after the introduction of vaccinations available to the general public, there has been a problem of a shortage of medical staff who have been involved in the work in additional wards as part of the fight against COVID-19. The response of the Medical Simulation Center in Poznan and giving special priorities to maximize accessibility was a very big challenge. The vaccination program against the SARS-CoV-2 coronavirus gives hope for a return to normality. For the extinction of the epidemic to become realistic, the threshold of herd immunity had to reach about 70 percent. This means that in the case of Poland, at least 26.8 million people should have coronavirus immunity. The number of trained people in 3 months reached an additional 1785 people, which can be assessed as a significant contribution of MCS for the population of the Greater Poland macroregion.

The decision to suspend classes at the Medical Simulation Center took place on 12.03.2020. The planned classes were canceled due to the growing threat related to the potential effects of the spread of the COVID-19 virus and were moved from the standard mode to remote tools. The downtime in classes at MSC forced organizational activities carried out on-site. The simulators were cleaned and disconnected from battery power sources, which lost their life with each day of standby. The trainers have been cleaned and disinfected with an emphasis on rubber tissues that become brittle and mold grow during non-use — e.g. trainers for intravenous, intradermal, and central injections. Audio systems and servers were shut down in accordance with the manufacturer's instructions to reduce wear and tear. During their remote work, simulation technicians were tasked with cataloging the Center's equipment, which teachers used to evaluate and use the equipment during their classes. The employees also took care of entering dozens of simulation scenarios into the database, which enriched the existing database of cases with another 320 ready-made automatic scenarios.

After the lockdown was lifted, face-to-face classes began to return first, including at the Medical Simulation Centre, and its role in the education of students of all faculties became crucial. Limitations in the functioning of teaching hospitals have increased the importance of the simulation environment, which has been adapted to conduct activities such as clinical activities based on simulation scenarios and diploma examinations (OSCE). At the end of 2021, some clinical classes were carried out in contact with simulated patients. To avoid possible accusations regarding the lack of implementation of specific procedures in the MSC by students and equally required during the exam, information videos were created on the organization, path of conduct, and functioning in the simulation environment, and the scope of verified procedures was confirmed with the learning outcomes that students obtained in the course of education.

The Covid-19 pandemic has caused an increase in interest in conducting classes at the Medical Simulation Centre. There was an increase in inquiries about the equipment and infrastructure capabilities to conduct new subjects. In the first place, classes using high-fidelity simulations, i.m.in e. internal medicine, internal medicine, professionalism, communication, and pediatrics, returned after the restrictions were eased, and classes with simulated patients returned in 2021 and were held under a sanitary regime [9–11].

Strengths and limitations

The presented work is a collection of chronologically executed multi-track activities implemented in the Medical Simulation Center during the ongoing COVID-19 pandemic. To the authors' knowledge, this is the first world comprehensive report of MSC activities during the pandemic time. Although the presentation of methodologies and results is difficult to assess qualitatively the impact on patient safety, it is a comprehensive report of non-statutory activities carried out at the MSC. Most of them were grassroots initiatives based on the enthusiasm of MSC employees, good preparation of medical simulation

trainers, as well as a spontaneous and understandable response to the epidemiological threat. It can be an excellent inspiration for the possibilities of using the know-how, humans, and hardware of training centers based on medical simulation techniques for future threats of a wide range. The multidirectional organizational and educational activities highlighted by the authors as a multi-profile activity of the MSC during the pandemic COVID-19 confirm the strength of the modern simulation center, especially in the flexibility in adapting to urgent health needs.

CONCLUSIONS

The multifaceted activity of the MSC confirms the great potential of this type of training unit based on medical simulation techniques as an educational tool, especially in the face of the real threat of a global epidemiological crisis. Although the long-term evaluation of results is difficult to estimate, the enormity of the completed tasks indicates a high adaptation and reorganization profile allowing for measurable results based on the unit's own resources. MSC can be an education center creating new procedures, standards of care, and best practices in difficult pandemic times.

Article information and declarations

Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics statement

Not applicable.

Author contributions

PZ, MP, MD, RM identified all presented activities. PZ, MP, MD, AD, BP, prepared SOP for ECMO and nursing management and ECMO courses curriculum. PZ, MD, AD, RM prepared POST structure and dedicated educational programs for volunteers and vaccination project. All authors PZ, MP, MD, AD, BP, RM read and approved the final manuscript.

Acknowledgments

The authors would like to indicate the important role of the technical staff of the Medical Simulation Center Poznan University of Medical Sciences and all trainers, facilitators, and volunteers in the initiation and development of all the activities during the COVID-19 pandemic.

Funding

Except the POWER funding — the project was awarded in 2018 funding from a POWER competitive national grant (POWR.05.04.00-IP.05-00-006/18) by the Polish Ministry of Health for a total of 2,750,000 USD (PLN 10,974,708.60), there was no other funding.

Conflict of interest

The authors declare no conflict of interest.

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VIA MEDICA

REVIEW PAPER

Disaster and Emergency Medicine Journal
2024, Vol. 9, No.3, 186–196
DOI: 10.5603/demj.100756

ISSN 2451–4691, e-ISSN 2543–5957

COVID-19 PANDEMIC AND THE CHALLENGES OF PRE-HOSPITAL EMERGENCY SERVICES IN IRAN: A SYSTEMATIC REVIEW

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ABSTRACT

INTRODUCTION: Emergency medical service (EMS) systems faced numerous challenges and issues as the frontline in dealing with the global Coronavirus Disease 2019 (COVID-19) pandemic. This systematic review aimed to prepare a guideline for managing future pandemics by exploring the challenges emergency medical technicians face in providing pre-hospital care during the COVID-19 pandemic.

MATERIAL AND METHODS: This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed, Web of Science (WOS), Scopus, ProQuest, Embase, Science Direct, and Google Scholar were the primary databases used to search for literature. The keywords used in this review were COVID-19, "Prehospital Emergency", and Iran, and their equivalents, obtained from MeSH, expert opinion, or related articles. From the 787 records identified through database searching in the early stage, after investigating, analysing the characteristics, and content analysis, 11 articles were included in the final stage of this review study to answer the study questions.

RESULTS: Based on the searches, 11 articles were finally evaluated. Challenges extracted from the analysis of studies were classified into 5 main themes, 12 subthemes, and 50 codes. The main themes include Ambiguity in operational protocols, Resource Shortage, Cultural challenges, Burnout, and Physical and Mental health challenges.

CONCLUSIONS: The outbreak of COVID-19 has presented challenges for pre-hospital emergency services (PHES) in Iran, necessitating adaptive strategies and coordinated efforts by authorities to prepare EMS for similar crises in the future.

KEYWORDS: COVID-19; pre-hospital emergency service; Iran

Disaster Emerg Med J 2024; 9(3): 186–196

INTRODUCTION

COVID-19 was first reported in Iran on February 19 and has since spread exponentially. The coronavirus has presented an unprecedented public health crisis, imposing an enormous healthcare burden on society with thousands of cases of illness and death [1]. The COVID-19 disease spread widely in Iran. After China and Italy, Iran had the third highest number of reported cases of COVID-19 at the beginning of the epidemic and was severely affected by the virus [2–4].

The significant rise in COVID-19 patients increased the exposure of pre-hospital emergency staff to the

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Recieved:19.05. 2024; Accepted: 13.05. 2024; Early publication date: 29.08.2024

virus [4, 5]. Emergency medical services (EMS) personnel are at the forefront of healthcare services and play a crucial role in managing public health crises, such as the spread of infectious diseases like COVID-19. As a result, they are exposed to significant psychological stress [6]. Numerous challenges in managing COVID-19 affect their performance [7].

Fagoni et al. [9] conducted a study in the Lombardy region of Italy and found that between 2019 and early 2022, the duration of missions and the time it took for the first vehicle to arrive at the scene of a stroke for COVID-19 pandemic patients increased. In another study by Stirparo et al. [9] in the same region, the results showed that the transfer duration of patients diagnosed with ST-elevation myocardial infarction from home to the hospital by pre-hospital emergency services during the COVID-19 pandemic also increased.

The PHES has never faced such an extensive disease, so the healthcare system managers and the staff were surprised. At the onset of the disease outbreak, there was often inadequate preparation in the pre-hospital emergency services to accommodate the large number of patients seeking assistance [10]. Numerous centres lacked facilities and equipment. Many emergency workers contracted COVID-19, and others feared passing it to their families. There was no clear process for treating and transferring patients who called the pre-hospital emergency; transfer instructions changed daily [11]. Due to the spread of the disease, all ambulances and pre-hospital emergency staff had to respond to the needs of COVID-19 patients and transfer them to the hospital if necessary, so they were constantly anxious and worried [12, 13]. Numerous studies have been conducted in Iran on PHES challenges during the COVID-19 pandemic. This systematic study was conducted to consolidate the findings and develop a guide for effective planning and enhanced management in future disasters.

METHODS

Design

This study is a systematic review of publications about the COVID-19 pandemic and the challenges of PHES in Iran. Data were collected using a clear process, and the study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The quantitative studies were heterogeneous, meaning that some had different designs, others had different participants, and the type of intervention was different or had different outcomes in some studies. Therefore, it was impossible to collect their conclusions and conduct a meta-analysis. The researchers conducted a content analysis to gather descriptive information. Rather than using pre-established categories, the authors identified words and phrases with similar meanings in the studies' texts to create the categories. In the initial analysis phase, they read the text multiple times to identify meaning units related to the study objectives. These meaning units were then condensed and coded [14].

Inclusion Criteria

The systematic review includes papers from various disciplines focusing on or related to the challenges of PHES in Iran. These papers were published from December 2019 to January 2024. This systematic review included studies found in reliable international databases of acceptable quality. The grey literature, including conference papers, research reports, theses, expert opinions, and key journals, was searched for additional studies. Additionally, the retrospective method (*i.e.* the reference lists of the included papers) and searches in Google Scholar were used as supplementary methods.

Exclusion criteria

For this study, book chapters and secondary studies, such as reviews and letters to the editor, and the studies that did not have an acceptable quality level were excluded. The search strategy did not impose any language limitations, but articles in languages other than English were excluded due to inaccessibility.

Search strategy

The valid electronic databases were searched thoroughly to identify relevant studies. The primary databases used to search literature were Scopus, PubMed/Medline, Web of Science (WOS), Science Direct, Embase, and ProQuest. Keywords included COVID-19, "Prehospital emergency", and Iran, and their equivalents, which were obtained from MeSH, Emtree, or extracted from expert opinion and related articles. Other resources, such as grey literature, reference lists of relevant primary studies, Google Scholar, and key journals, were searched for additional studies. Articles published from December 2019 to January 2024 were included. The study

syntax was formed from 3 components. The first component included Corona OR Coronavirus OR Covid-19 OR "novel coronavirus" OR "SARS coronavirus" OR "COVID pandemic" OR "coronavirus disease" OR "coronavirus outbreak" OR "severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2" OR "SARSCoV" OR "MERS-CoV" OR "coronavirus disease 2019" OR "COVID-19 pandemic" OR "new coronavirus disease"; the second component included EMS OR 115 OR "pre-hospital emergency" OR "Pre-hospital EMS" OR "Emergency Medical Service" OR "Medical Technician" OR Paramedic* OR "Emergency Paramedic" OR PEMS OR "Emergency Medicine Technician" OR "Emergency Medical Technician" OR "Emergency Prehospital Provider"; and the third component included Iran. The search syntax is shown in Supplemental Material 1.

Data extraction (selection and coding)

First, a thorough literature search was performed using the key terms in databases including PubMed (including Medline), Web of Science, Scopus, ProQuest, Science Direct, Embase, and Google Scholar (P.D, M.B, S.J, and R.A.S), then the title and abstract of the found articles were evaluated to exclude the unrelated ones (P.D, M.H, M.B, and R.A.S.). Then, according to the inclusion and exclusion criteria, the eligibility of the full texts of the remaining articles was assessed by 2 reviewers. Any disagreement was resolved by consensus between the 2 authors (M.H, R.A.S).

Quality assessment

The full texts of the articles were read and checked by 2 authors independently for the quality of the included studies. The Critical Appraisal Skill Program (CASP) and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) were used to assess and evaluate qualitative and cross-sectional studies. In this review, due to the difference in methodology and the heterogeneity of the articles included in the final stage, it was impossible to perform a meta-analysis. To assess the quality of the studies and determine if they should be included in the final analysis, the authors used the STROBE tool for cross-sectional studies and the CASP tool for qualitative studies. A cutoff point of 60% was set, meaning that studies that met at least 60% of the STROBE or CASP criteria were included in the final analysis, while those that did not meet this threshold were excluded from the study.

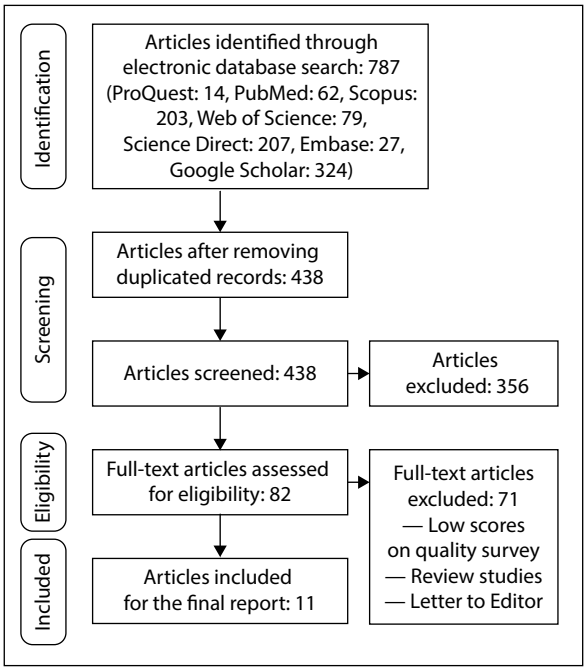

FIGURE 1. Review selection process and results based on the PRISMA guidelines

RESULTS

From the 787 articles identified through the early electronic database search, 11 were selected for this review, followed by an analysis of the characteristics and content of the included studies to answer the study questions (Fig. 1). Of the 11 selected studies in the final round, 5 had a qualitative design, 5 were descriptive cross-sectional, and one was mixed method (Tab. 1).

Implementing quantitative analysis was impossible, so content analysis was done to obtain descriptive information. The articles included in the final stage had various methodologies, and the quantitative data were heterogeneous. The findings of the content analysis were summarised in 5 themes (ambiguity in operational protocols, resource shortage, cultural challenges, burnout, and physical and mental health challenges) (Fig. 2), 12 subthemes, and 50 codes, which are described in order (Tab. 2).

Ambiguity in operational protocols

During the COVID-19 pandemic, the lack of defined protocols and fixed methods caused confusion and ambiguity for pre-hospital emergency services personnel [13, 15, 16]. Due to the newness of COVID-19, there were frequent changes in protocols, guidelines, and medications. This confused pre-hospital emergency personnel as new medicines were

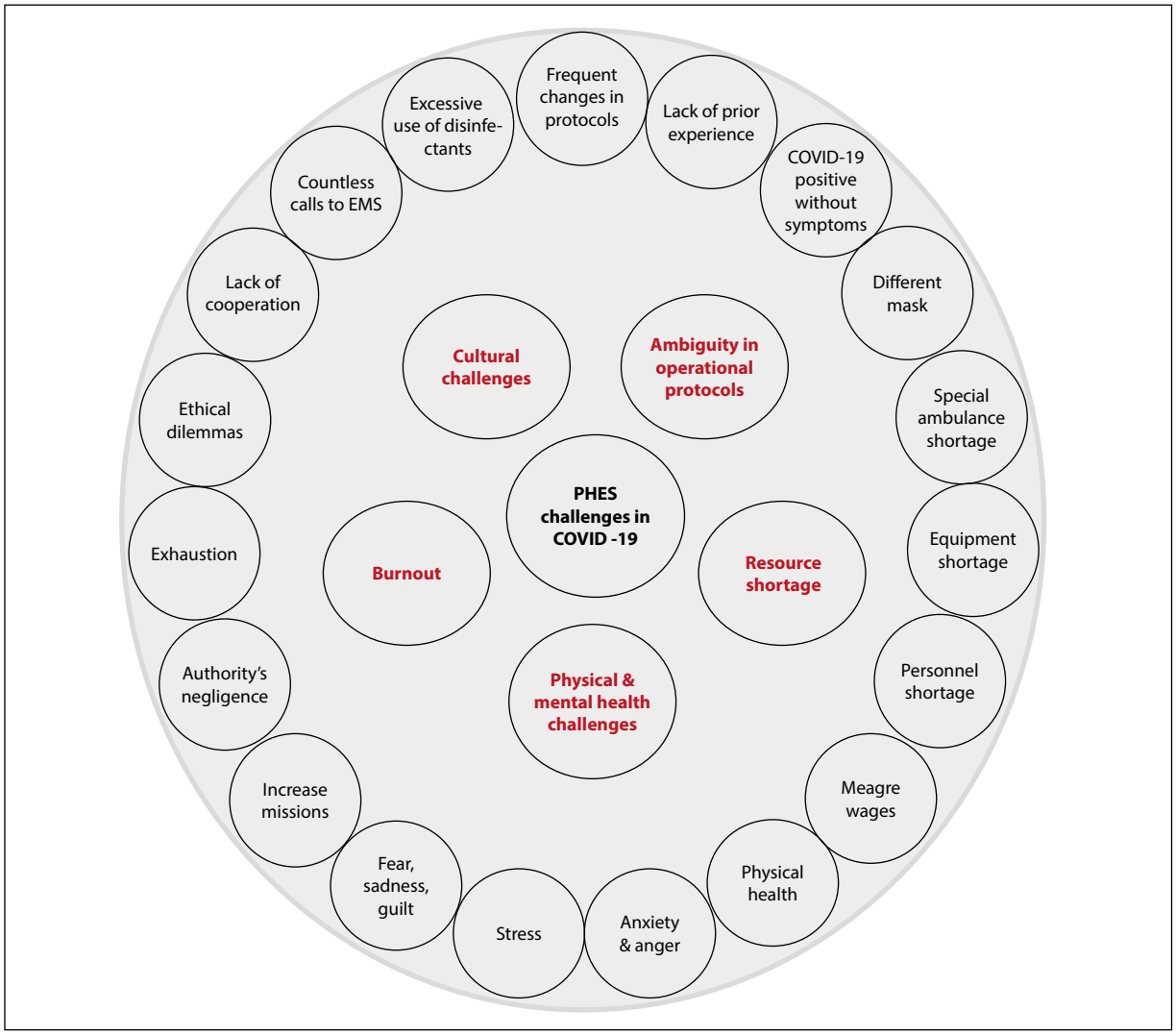

FIGURE 2. The challenges of PHES in COVID-19 pandemic

sought and previous ones were abruptly discontinued. Another challenge was the lack of a referral system for COVID-19 patients [17].

Several challenges need to be addressed in the emergency medical services sector. These include the lack of prior experience among medical staff, uneven distribution of pre-hospital emergency centres in urban and remote areas, and disagreements between hospital and pre-hospital emergency staff over admitting patients with no available beds [17–19].

Resource shortage

Human resources: The shortage of pre-hospital emergency personnel presented a significant challenge during the coronavirus outbreak, while the lack of personnel has consistently been an issue under normal conditions. Due to the rapid spread of COVID-19, the shortage of pre-hospital emergency personnel became a critical issue. Due to the crisis, staff members were not allowed to take absences, and replacements were unavailable due to manpower shortages. As a result, many employees fell ill, putting more pressure on their coworkers to work extra shifts [11, 13, 15].

There were a couple of challenges that arose about personnel management. Firstly, hiring less experienced personnel proved to be a challenge. Secondly, the personnel lacked awareness and preparation for the coronavirus and were unsure how to handle the crisis. Studies also highlighted insufficient training, particularly about proper use of personal protective equipment and disinfecting ambulances [18, 19]. Hiring inexperienced employees during the COVID-19 pandemic, with an uncertain future and a high likelihood of being unemployed again after the virus was under control, posed another challenge for human resources [17]. The lack of support from

Table 1. The characteristic of included studies

No	Author(s)	Year	Aim	Methods	Results
1	Ardebili ME, et al.	2021	To undertake an in-depth exploration of the experiences of healthcare staff working during the COVID-19 crisis.	Qualitative study	Experiencing different emotions in EMS staff, providing mental health aid should thus be an essential part of services for healthcare providers during the pandemic.
2	Hadian M, et al.	2022	To explore pre-hospital emergency challenges in the face of the COVID-19 pandemic.	qualitative content analysis	lack of equipment and job overload, Lack of public awareness and Procedural and infrastructural challenges were the main challenge of EMS staff against covid-19.
3	Heidari M, et al.	2022	To identify the challenges of prehospital emergency system function in the face of COVID-19 pandemic.	Qualitative approach	Four main challenges were extracted: challenges related to facilities and equipment, living with uncertainty, professional and organizational capabilities, and burnout.
4	Salami Z, et al.	2023	To investigate perceived stress and coping strategies among ED nurses and EMS staff.	Descriptive-cross-sectional	The most stressful factors were related to the transmission of the disease to the family and seeing the death of COVID-19 patients in front of their eyes.
5	Asadi H, et al.	2022	To determine depression, anxiety, and stress in prehospital emergency personnel during the COVID-19 epidemic.	Descriptive cross-sectional study	More than half of the staff had moderate to severe depression and anxiety.
6	Sabbaghi M, et al.	2022	To investigate depression, anxiety, and stress levels of the Iranian prehospital emergency personnel during the COVID-19 pandemic.	Descriptive cross-sectional	Prehospital emergency personnel suffer from significant levels of depression, anxiety, and stress during the COVID-19 pandemic.
7	Ghezelbash, S et al.	2022	To investigate the correlation between mental health and corona anxiety among pre-hospital emergency medicine clinicians during the COVID-19.	Cross-sectional study	The anxiety created due to the outbreak of Corona virus among pre-hospital emergency workers has affected their mental health.
8	Parvaresh-masoud M, et al.	2021	To identify the challenges that EMS staff face in their daily work and develop strategies that addresses these challenges.	Qualitative study	The challenges were classified into three main categories including "restless society", "difficult care delivery conditions", and "unprepared organization".
9	Sadeghi M, et al.	2023	Exploring the challenges of EMTs in providing pre-hospital care during the COVID-19 pandemic.	Qualitative research	Challenges among EMTs during the COVID-19 pandemic were categorised under 4 themes including: work factors, unprepared organization, threatened health, restless social.
10	Mohammadi F, et al.	2021	To identify some strategies to manage the COVID-19-related challenges faced by the pre-hospital emergency care personnel.	Qualitative descriptive study	Due to lack of equipment and work overload in the current crisis, emergency medical services personnel are faced with many psychological challenges.
11	Heidari M, et al.	2022	To investigate the level of anxiety and professional competence of pre-hospital emergency medical personnel in the COVID-19 epidemics.	Descriptive-analytical study	The stress and anxiety of the COVID-19 epidemic have adverse effects on the professional competence of pre-hospital emergency medical personnel as well as their mental health.

Table 2. Extracted themes and subthemes

Theme	Subtheme	Codes
Resource shortage	Personnel shortage	Permanent shortage of staff under normal conditions Absence due to increased workload during the COVID-19 pandemic Absence due to coronavirus infection
	Equipment shortage	PPE shortage Disinfectant shortage Multiple uses of disposable items
	Meagre wages	Low salary Unfair salary payment Lack of support from officials
	Special ambulance shortage	Ambulance shortage Shortage of special ambulance for COVID-19 patients Transporting both COVID-19 patients and non-COVID-19 patients in the same ambulance. The fear of non-corona patients being transported in an ambulance that is also carrying a COVID-19 patient. Conflict with emergency personnel because of shared ambulance with COVID-19 patients
Ambiguity in operational protocols	Frequent changes in protocols	Changes in COVID-19 patient management Recommendation to use different masks Change in medications Corona-positive patients without symptoms Symptomatic patients with negative COVID-19 test
	Lack of prior experience	The outbreak of a pandemic for the first time for EMS personnel Use of inexperienced personnel Inadequate training
Cultural challenges	Ethical dilemmas	Making the right decisions in difficult situations Respecting the rights of patients Preferring others over oneself
	Lack of community cooperation	Not wearing mask Failure to follow protocols Increase in EMS calls Unnecessary calls Excessive use of disinfectants and contact with EMS due to their side effects
Burnout	Exhaustion	Increase missions Work in difficult conditions Increase working hours Frequent changes in the work environment due to staff shortage Long-term wearing of PPE Being away from family
	Negligence of the authorities	Not providing enough staff Paying low wages Forced to do overtime
Physical & mental health challenges	Physical health	Body pain Headache, insomnia Itching and skin problems due to PPE and disinfectants
	Mental health disorders	Anxiety about getting infected with COVID-19 Fear of passing the infection to the family Self-quarantine Fear of death Death of patients and colleagues Feeling of guilt if the family gets infected Anger at being quarantined The feeling of hopelessness and despair

authorities during the challenging situation of the coronavirus pandemic was also mentioned as a significant obstacle in several articles [15–18].

Financial resources: During the COVID-19 pandemic, numerous studies highlighted the insufficient financial resources available to pre-hospital emergency personnel. Furthermore, there was little support and attention given to them. In most cases, personnel salaries were reported to be very low and unfair, and equipment shortages have also been a major challenge. The discrepancy in fee payments between pre-hospital emergency workers and hospital workers and the higher salaries in certain privileged provinces compared to disadvantaged provinces led to frustration and low morale among pre-hospital emergency personnel [20, 21].

Equipment: All studies indicated a shortage of personal protective equipment and disinfectants during the COVID-19 crisis and an unfair distribution of masks and clothing [13, 17, 19]. The price of personal protective equipment increased while the quality decreased [13]. Due to equipment shortages, time constraints, and multiple missions, personnel often reused suits and masks and sometimes wore the same mask for extended periods [19, 20]. Furthermore, the ambulances were inadequately equipped, and no ambulances were designated specifically for transporting COVID-19 patients. The lack of dedicated ambulances meant that COVID-19 patients were transported in the same ambulances as other patients. This led to dissatisfaction among some patients, and in some cases, it even resulted in conflicts between the emergency personnel and the patients' companions [21, 22].

Physical and mental well-being

During the COVID-19 pandemic, the physical and mental health of pre-hospital emergency personnel was compromised, leading to the publication of numerous articles addressing these issues [21].

Physical health: Long working hours and using personal protective equipment and masks resulted in body aches, headaches, insomnia, itching, and skin problems among PHES personnel [15].

Mental health: The COVID-19 crisis brought about various psychological challenges for pre-hospital emergency staff, including anxiety, fear, stress, sadness, and guilt [23, 24]. According to a study, EMS staff experienced moderate to severe anxiety during the COVID-19 crisis. Staff members with higher levels of anxiety reported poorer overall general health [11]. Another study found a correlation between higher anxiety levels and EMS personnel who had families affected by COVID-19. This study also noted a connection between anxiety levels and professional competence [13, 25].

During the quarantine and social isolation period, mental health concerns were further exacerbated, leading to increased levels of anger and anxiety among individuals. The heavy workload also caused conflicts within families and changes in personal daily routines. Some studies showed that individuals experienced post-traumatic stress disorder (PTSD) and reduced flexibility [25]. The lack of attention to the psychological well-being of individuals by authorities was also highlighted in articles, and this should be addressed promptly. Anxiety was widespread during that time due to various reasons, including the fear of getting sick, concerns about the severity of the disease, anxiety about death, worries regarding transmitting the illness to loved ones, and the fear of dying without any support [26]. Witnessing others suffer and die from illness can lead to sadness and guilt if unknowingly spread to family members [27].

The COVID-19 pandemic has increased workloads, leading to family conflicts and arguments. Personnel and their families are worried about the changes in their daily routines, which has increased feelings of hopelessness as the pandemic persists. The lack of control over the situation has caused heightened distress, and motivation among personnel has declined over time. Efforts feel futile, and treatments seem inadequate. The exhausting workload has worsened mental and psychological strain, resulting in severe fatigue among personnel [26–28].

Burnout

During the COVID-19 pandemic, there was a significant increase in emergency calls and missions, leading to healthcare workers having a heavy workload and working long hours. The use of personal protective equipment also contributed to the exhaustion experienced by the personnel, especially during hot weather, as it caused sweating and loss of appetite. Additionally, healthcare workers faced the challenge of distinguishing between COVID-19-positive and non-COVID-19 patients [17].

Ethical dilemmas were highlighted during this period, such as making difficult decisions, respecting patient autonomy, prioritising others' well-being,

and risking personal health for patients [15, 28, 29]. Disregarding the guidance of emergency officials and healthcare authorities, low wages, neglect of staff shortages, excessive work pressure on existing personnel, and forcing them to work overtime led to frustration and extreme fatigue among the personnel [15, 28–31].

Cultural challenges

The pre-hospital emergency department encountered several challenges due to the public's lack of understanding of the COVID-19 pandemic, which resulted in a lack of cooperation. Anxiety among the population led to numerous unnecessary phone calls to the pre-hospital emergency department, some of which were cases of harassment. Many individuals did not follow health protocols, such as wearing masks. Additionally, some patients provided incorrect information and lacked proper cooperation, exacerbating the situation. Excessive use of disinfectants led to complications such as skin, eye, and lung problems, coughing, and shortness of breath, which increased the number of phone calls related to these issues [13,14, 29]. During this period, ethical dilemmas were highlighted: making difficult decisions, respecting patient autonomy, prioritising others' well-being, and risking personal health for patients [15].

The results of a systematic study conducted by Eftekhari et al. [32] in 2023 to investigate the challenges of PHES in different countries in the face of COVID-19 showed that the main challenges in this field are lack of equipment, inappropriate management, lack of human resources, lack of protocols and guidelines, weak training of employees, burnout, and weak social-organisational support.

One of the limitations of this study is the lack of sufficient internal and external research in the field of PHES and the COVID-19 pandemic, which can be useful in comparing and matching the results of this research with other national and international research.

CONCLUSIONS

PHES encountered numerous challenges during the COVID-19 pandemic. This unprecedented experience can enhance resilience and help to better prepare for future disasters. Targeted planning, providing appropriate infrastructure, adequate equipment, suitable and sufficient personal protective equipment, ensuring adequate training and deployment of staffing, ongoing in-service training, psychological and financial support for staff, providing assistance to the families of staff during critical situations, promoting public education for community collaboration, and the companionship and empathy of senior officials with employees can form the foundation for creating a resilient PHES in future disasters.

Also, according to the principles of disaster management, in the preparation phase, hazards and vulnerabilities (lack of equipment and staff, burnout, lack of training, *etc.*) should be identified, and efforts should be made to eliminate also, increase capacities, like: specialized training of personnel, equipment, facilities, and have a preparedness plan, *etc.*

Article information and declaration

Author contributions

RAS and MH designed the study. PD, MBK, and SJ collected data. RAS and MH analysed the data. All authors contributed to the analysis and interpretation of data. RAS and MH drafted and revised the article according to the other authors' comments. All authors approved the final version.

Funding

The project was financially supported by Shahrekord University of Medical Sciences, Shahrekord, Iran (Grant No.7246).

Acknowledgements

This study is related to a research design that was ratified and Financial Support by the research and technology deputy of the Medical Sciences University of Shahrekord (Grant No. 7246). I hereby express my deep gratitude toward the respectable Deputy of Research and Technology, also Community-Oriented Nursing Midwifery Research Centre of Shahrekord University of Medical Sciences.

Ethics statement

The present study was approved by Ethical Committee Medical Sciences University of Shahrekord (Ethics code: IR.SKUMS.REC.1402.140).

Conflict of interest

None.

Supplementary material

Suplementary material 1 — The search syntax.

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Suplementary Material 1. The search syntax	
Databases	**Search syntax**
PubMed	(((Coronavirus[tiab] OR "novel coronavirus disease"[tiab] OR "SARS coronavirus"[tiab] OR "severe acute respiratory syndrome coronavirus 2"[tiab] OR "SARS-CoV-2"[tiab] OR "SARSCoV"[tiab] OR "MERS-CoV"[tiab] OR "coronavirus disease 2019"[tiab] OR "COVID-19"[tiab] OR "COVID-19 pandemic"[tiab] OR "coronavirus 2019-nCoV"[tiab] OR "new coronavirus disease"[tiab] OR "coronavirus outbreak"[tiab]) AND (EMS[tiab] OR «Emergency Medical Service"[tiab] OR "Prehospital Emergency Service*"[tiab] OR «Pre-hospital Emergency Medical Service"[tiab] OR "PEMS"[tiab] OR "Pre-hospital EMS"[tiab] OR 115[tiab] OR "Medical Technician"[tiab] OR Paramedic*[tiab] OR "Emergency Paramedic*"[tiab] OR "Emergency Medicine Technician"[tiab] OR "Emergency Medical Technician*"[tiab] OR "Emergency Provider"[tiab]) AND (iran[tiab] OR iran[pl] OR iran[ad]) AND (2019/01/01:2024/01/05[dp])
WOS	(Corona OR Coronavirus OR Covid-19 OR "novel coronavirus" OR "SARS coronavirus" OR "COVID pandemic" OR "coronavirus disease" OR "coronavirus outbreak" OR "severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2" OR "SARSCoV" OR "MERS-CoV" OR "coronavirus disease 2019" OR "COVID-19 pandemic" OR "new coronavirus disease") (Topic) and (EMS OR 115 OR "pre-hospital emergency" OR "Pre-hospital EMS" OR "Emergency Medical Service" OR "Medical Technician" OR Paramedic* OR "Emergency Paramedic" OR PEMS OR "Emergency Medicine Technician" OR "Emergency Medical Technician" OR "Emergency Prehospital Provider") (Topic) AND Iran(Address) AND Timespan: 2019-12-31 to 2024-01-04 (Publication Date)
ProQuest	TI, AB(Corona OR Coronavirus OR Covid-19 OR "novel coronavirus" OR "SARS coronavirus" OR "COVID pandemic" OR "coronavirus disease" OR "coronavirus outbreak" OR "severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2" OR "SARSCoV" OR "MERS-CoV" OR "coronavirus disease 2019" OR "COVID-19 pandemic" OR "new coronavirus disease") AND TI,AB(EMS OR 115 OR "pre-hospital emergency" OR "Pre-hospital EMS" OR "Emergency Medical Service" OR "Medical Technician" OR Paramedic* OR "Emergency Paramedic" OR PEMS OR "Emergency Medicine Technician" OR "Emergency Medical Technician" OR "Emergency Prehospital Provider") AND location (Iran) AND YR(> 2019)
Scopus	TITLE-ABS-KEY [(coronavirus OR "novel coronavirus disease" OR "SARS coronavirus" OR "severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2" OR "SARSCoV" OR "MERS-CoV" OR "coronavirus disease 2019" OR "COVID-19" OR "COVID-19 pandemic" OR "2019-nCoV coronavirus disease" OR "coronavirus 2019-nCoV" OR "new coronavirus disease" OR "coronavirus outbreak")] AND TITLE-ABS-KEY [(ems OR «Emergency Medical Service» OR «Prehospital Emergency Service» OR «Pre-hospital Emergency Medical Service» * OR «PEMS» OR «Pre-hospital EMS» OR 115 OR «Medical Technician*" OR paramedic* OR "Emergency Paramedic*" OR "Emergency Medicine Technician*" OR "Emergency Medical Technician*" OR "Emergency Prehospital Provider*")] AND AFFILCOUNTRY (Iran) AND PUBYEAR > 2019