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EDITORIAL ARTICLE

Artificial Intelligence and the practice of emergency medicine

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ABSTRACT

Since the introduction of the Generative Artificial Intelligence (AI) tool "Chat GPT" in the fall of 2023, a new era in clinical diagnostics and clinical decision-making has begun, both within medicine in general and within emergency medicine in particular. These new "Generative AI" tools can be expected to influence and modify the clinical practice of emergency medicine, because they can derive new data and generate non-human generated rules, in a manner that prior "generations" of AI tools could not do. Therefore, to enable a fuller understanding of how and why Generative AI differs from prior AI tools, a review of the four "generations" of AI is first presented, with reference to some commonly known tools and outcomes related to each of these four "generations". Then, having established how "Generative AI" represents the fourth and most recent version of AI, selected current and anticipated near-future impacts of that Generative AI upon the specialty of Emergency Medicine are discussed. The examples cited in this manuscript are illustrative but not exhaustive, as this field of inquiry is rapidly changing and updating. Hopefully, this publication will stimulate the reader to become more alert regarding how Generative AI is influencing their practice, and to become receptive to current and near-future changes of the practice of emergency medicine that will derive from the application of Generative AI tools in the emergency caregivers' workplaces.

KEY WORDS

Artificial Intelligence, emergency medicine, clinical decision support systems, diagnostic techniques and procedures

INTRODUCTION

Since the "rollout" of the 'Generative" Artificial Intelligence (AI) tool "ChatGPT" in the fall of 2023, interest in the topic of AI among physicians of all specialties has grown exponentially. This interest is not unique to physicians. Quickly after its release in the fall of 2023, ChatGPT quickly become the most widely and rapidly disseminated technology in history [1]. Interest in "Generative" AI (GAI) has exploded, because GAI tools can do things prior versions of AI could not, such as create new text and images. Such capability is of natural interest to physicians.

A clear and accurate definition of "GAI" is offered by the United States' National Library of Medicine. Generative Artificial Intelligence (AI) is a system of algorithms or computer processes that can create novel output in text, images or other media based on user prompts. These systems are created by programmers who train them on large sets of data. The AI learns by finding patterns in the data and can then provide novel outputs to users' queries based on its findings. Generative AI systems are distinguished from other AI systems by their ability to create novel output [2].

Thus, the term "generative" implies that the GAI has acquired two new capabilities. One is to derive new data. The other is to create new, non-human-created rules to be applied, allowing new interpretations of data that emerges from interactions such as those that occur between doctors and patients.

It is difficult to identify any aspect of modern life that is not likely to become influenced by AI in general and GAI in particular. Thus, physicians who previously had little regard for AI have suddenly had reasons to become interested. It would be easy for anyone to feel overwhelmed by the rapid advances in the field of AI. However, many physicians have not only grown interested in AI, they have also begun to utilize it in their workplaces. Because of the interest of many emergency physicians in AI, this manuscript ends with a focus upon how AI and GAI can be expected in the near-future to influence the practice of medicine in general and our specialty of emergency medicine (EM) in particular. However, before ending with this focus, a review of the "generations" of AI will be presented, to make the reader more knowledgeable about how the capabilities of AI have grown across the past several decades.

In the English language, the term "sound bite" is a slang expression that implies a short sequence of words which captures a larger meaning, both effectively and efficiently. A "sound bite" regarding how AI can be expected to influence the practice of medicine has been offered by former American Medical Association (AMA) President (2023-24) Jesse Ehrenfeld MD. Dr Ehrenfeld is an anesthesiologist, a medical informaticist and faculty member of the Medical College of Wisconsin. When being interviewed by a reporter from the magazine Politico, he stated, "It is clear to me that AI will never replace

physicians — but physicians who use AI will replace those who don't" [3].

AI OVERVIEW: THE "GENERATIONS" OF ARTIFICIAL INTELLIGENCE (AND SELECTED SOCIETAL AND MEDICAL IMPACTS)

Artificial Intelligence can mean different things to different people. Toward cultivating a more uniform understanding of this topic, a brief overview some of the achievements of AI, stratified by describing the four distinct "generations" of AI, will be illustrative. As noted above, only recently has AI advanced to the point of being able to generate new data, which is GAI.

Prior "generations" of AI which existed before the last quarter of 2023 were able to manipulate and apply existing data. They could also apply data management rules created by humans. However, these forms of AI were unable to generate new data on their own. They also could not create or apply rules derived by the AI itself. This all changed with the onset of GAI.

GENERATION 1 OF AI: RULE-BASED SYSTEMS AND SEARCH ENGINES

An early use of AI became known in the 1990s in "popular culture". That was the creation and deployment of "first generation" AI, which enabled a machine designed and programmed by a team of humans to eventually defeat the reigning world chess champion. This famous series matching "man" versus "machine" occurred first in 1996 and then in 1997. In both years, the player that won a majority of six matches was declared the winner.

In 1996, world chess champion Garry Kasparov played six matches in Philadelphia, Pennsylvania against a newly-programmed computer called "Deep Blue". "Deep Blue" was built and programmed by a team from International Business Machines (IBM), with the express goal of defeating Kasparov. In 1996, Kasparov defeated "Deep Blue" by a score of four matches (Kasparov) to two (Deep Blue) [4, 5].

However, by 1997, upgrades of "Deep Blue" enabled the machine to defeat the man. When Kasparov conceded the sixth match in New York City that year, Deep Blue became the series winner, by a score of three and one-half matches for "Deep Blue" to two and one-half for Kasparov [4, 5].

Such first generation AI, as exemplified by "Deep Blue", utilized rule-based systems designed humans, built to simulate a human's decision-making. All of the programming of "Deep Blue" was done by humans, informed by Kasparov's prior chess match moves and decisions. This programming determined how "Deep Blue" operated [6].

"Deep Blue" represented an advance, but it was far from being generative AI. In fact, "Deep Blue" (and other early forms of 1st Generation AI) could not even quickly search information, in the manner by which search tools such as "Google" have accustomed us all. Further, at this point of development, AI tools were quite limited. They could not handle ambiguity, they could not adapt to solve complex problems beyond the instructions programmed by their programmers, and they could not learn new information from the data it encountered. First Generation AI was limited to the rules that humans gave it [6].

This is not to say that "First Generation" AI did not become adapted for medical uses. Among the uses of "First Generation" AI in medicine were decision-making tools such as antibiotic selection guides. An antibiotic could be suggested, based upon a microbe being "Gram Positive" or "Gram Negative", and upon whether the microbe was an aerobic or anaerobic organism, as well as the organ system(s) involved [7].

This was but one example of "Rule-Based Decision Support" that First Generation AI could provide to enhance Electronic Health Records (EHRs). Nonetheless, the key point remains: First Generation AI was and is unable to solve new problems, derive new solutions or make new inferences.

Also, no discussion of later editions of "First Generation" AI would be complete without a mention of "search engines", as exemplified by the pervasive tool called "Google", but which also had prior iterations of software that has become less utilized, such as "Yahoo", "Ask Jeeves", and others. These tools influenced medicine and medical education by enabling much more rapid data searching by professionals and by learners. Gone became the days remembered by those of us in our third or fourth decade of medical practice, when a data search to answer a medical question began with a painstaking review of numerous years' annual copies of the "Cumulated Index Medicus".

By the late 1990s, the availability of such "search engines" led to reform of the curriculum of many medical schools, as students quickly learned to adapt these tools, often before their faculty incorporated them into the curriculum. Curricular reform led to less emphasis on in-person lectures and more reliance on student-assembled case and data search presentations, which required the learner to demonstrate not only subject matter mastery, but also integration of data and critical thinking skills [8].

GENERATION 2 OF AI: "MACHINE LEARNING"

The "Second Generation" of AI, that of "machine learning", provided incremental progress, but came nowhere near the capacity to be "generative", let alone the capacity to rapidly search large bodies of data. However, the development of this "generation", characterized by a new ability for networks themselves to "learn" from data, was hastened by improved microprocessor speeds and capacity that were developed shortly after the turn of the century.

These new AI systems could not only learn from data. They also acquired a limited capacity to create rules derived from data that had been collected. Thus, they became free of the constraint that a human must create all rules by which the system operates. This is why this era is called the era of "Machine Learning".

However, their microprocessor speeds fell far short of modern capabilities, and they could not yet be exposed to sufficiently large quantities of data to create accurate

and medically useful models de novo [6]. These tools could not generate reliable new data on their own.

Within medical care, the impact of second-generation AI was primarily in studies of feasibility, and any clinical impact of this AI was highly limited. This limitation was largely due to the complexity of clinical data overwhelming a relatively low availability of data at that time, compared to the current era. Also, most machine learning approaches of this "generation" used "Supervised learning". "Supervised Learning" required data to be derived from data sets that had been curated by humans, or had defined outcomes. This meant that human experts had to classify outcomes that were observed clinically, in order to train machine learning models [9].

As stated by Wilcox et al., "Ultimately, due to this curation cost, and broader challenges with machine learning performance, most machine learning projects in medicine outside of bioinformatics and genetics failed to move beyond the experimental stage [6]."

Thus, to summarize, studies of feasibility of future planned developments (to become enabled only if better hardware and more data access were available) began to appear, but the actual impact of "Second Generation AI" upon the medical profession was quite limited.

GENERATION 3 OF AI: "DEEP LEARNING"

The next major breakthrough in AI arose early in the 2010s, with the advent of "Deep Learning". "Deep Learning" is an enhanced subset of machine learning [10]. "Deep Learning" was enabled by two factors. One was a rapid growth of available data that could be used for machine learning. (Data availability limitations had limited second generation AI, as noted above). The other factor was increased computer microprocessor speed and processing capabilities.

The onset of "Deep Learning" also coincided with the era of "Big Data" and the emergence of fast graphics processing units (GPUs) for processing of data. "Deep learning" became possible because it leveraged a new type of machine learning algorithms, "Artificial Neural Networks". Artificial Neural Networks have "nodes" that enable the learning of higher-level features from raw data than is possible without these nodes. This allowed for greater abstraction and more powerful modeling of complex datasets [6].

In addition, neural network models, once developed, are highly efficient. This efficiency derives from their use of direct numeric calculations with the variables among the nodes in the networks. With more data and processing capabilities, deep learning allowed discovery of patterns that could not be identified during the previous machine learning era without substantial use of domain knowledge in the process [6].

In medical care, perhaps the best-known influences of "Third Generation" AI in medicine were in the field of machine-enhanced "image recognition" for the specialty of Radiology and in the field of "speech recognition" for voice dictation systems.

For image recognition, AI became able to detect subtle findings and/or to suggest possible "misses" committed by the human. This leveraged the fact that humans can become fatigued, but machines cannot.

Modern user-trainable voice dictation systems and mobile phones have also become enabled by this generation of AI. Voice dictation system users still need to speak and enunciate speech clearly, but modern systems make less transcription errors than earlier versions. Further, most of us have had the experience of typing a text message on our mobile phones, then having the phone's software suggest the next word likely to be desired in that message.

Another field of medicine most notably impacted by the capabilities of Third Generation AI was Genetics [11], as could be expected from the facts that the human genome is comprised of huge quantities of bits of data. However, genetic matters are generally far afield from the usual considerations of an emergency physician.

Enhanced image recognition has been applied in "popular culture" toward the development of "self-driving" motor vehicles [6]. Steps toward this goal have been incremental. For instance, my own model 2017 Chevrolet Volt motor vehicle had "blind spot" sensors that activated a light in the vehicle's side mirrors when a vehicle was in proximity. That car also had automated braking systems that became activated if another object was too close or if the "closing speed" to that object was excessive. Further, the "Cruise Control" system of that car enabled programming of the desired vehicular speed and would slow the vehicle when it approached too closely behind another vehicle traveling the same path. Finally, this Chevrolet Volt was a "hybrid" which had both petroleum-powered and electrically powered propulsion systems, and the vehicle could seamlessly bring the petroleum-powered engine into use once the electrical power system's battery became exhausted.

Progress in this decade has yielded vehicles with systems that can warn the driver when they are wandering out of their lane without signaling a lane change, and that can suggest that a driver's pattern of weaving erratically might suggest a need for a rest stop. I personally own one of such vehicles, a 2024 model year Kia Niro.

However impressive these developments may be, these vehicles have not yet gained the self-sufficiency that would enable deployment of such vehicles without a need for the operator to maintain vigilance that would enable overriding AI-generated driving errors.

Critics will point out that "self-driving" cars have caused human fatalities, such as vehicle versus pedestrian or vehicle versus bicycle crashes. However, fairness requires recognition that human drivers also cause numerous errors. In the United States in 2024, there were more than 44,000 motor vehicle crash fatalities in human-driven cars [12], and the worldwide annual fatality toll from motor vehicle crash deaths was thought to be on the order of 1.2 million individuals [13]. One can reasonably expect that we will live to see not only highly

capable self-driving motor vehicles for roadway travel, but perhaps even self-operated helicopters or airplanes that operate without a pilot. Generative AI may not only become leveraged to enable these outcomes. It may do so with a greater degree of safety than humans can provide. Already, the day has been envisioned in which generative AI will produce high fidelity simulated driving environments at much lower cost than is possible today [14]. If simulation can be made less expensive, self-driving vehicles should eventually become more probable.

GENERATION 4: "GENERATIVE" AI

As noted above, after its release in late 2023, the "Generative AI" tool "ChatGPT" became the most widely and rapidly adopted technology ever [1]. The distinguishing feature of "ChatGPT" and other "Generative" AI is the capacity to develop new data de novo. For instance, these software can assemble a person's biography, in a form which imitates that which would be written by a human, after exposure to sufficient data about a person's background and past [15]. They also can take human-input facts and their own conclusions to assemble capably-written drafts of scientific papers [16].

This is not to say that generative AI is "foolproof". AI needs "guardrails" [17]. Erroneous output that is not fact-based is known as a "hallucination" [18], and humans still need to oversee generative AI output with a vigilance to detect hallucinations when they occur and correct them as necessary [17].

A useful thought model can be cited to explain why vigilance against machine-derived hallucinations is so crucial. Consider the manner by which some calculator users will accept a calculator's answer to a math operation as inherently correct, while an experienced observer would quickly detect that an mistake has occurred somewhere in the calculation process, leading to an obvious error. Those who blindly accept calculated numbers as correct sometimes fail to recognize that an apparent answer to a problem mis-states the answer by an order of magnitude or more. Such errors were especially prevalent in medicine when nurses or doctors would hurriedly calculate infusion drip rates for vasoactive drugs, before pharmacies began supplying standard mixes of drugs with charts to permit the user to match the patient's size and drug dose to the medication's infusion rate.

The "take-away" is that "guardrails" are needed to prevent machine "hallucinations" from harming patients via the provision of faulty information. At this time, humans must provide the greatest portion of these "guardrails" [17, 18].

All of this about hallucinations is not to detract from some tremendous achievements by generative AI. Generative AI has achieved high scores in the United States on its Law School Admissions Test (LSAT) (62nd percentile of first-time test takers) [19] and Medical College Admissions Test (MCAT) [20]. It has also performed as well as many experienced physicians on the United States Medical Licensure Exam (USMLE) [21] and other written board specialty certification or re-certification examinations in other nations [22-24].

Another "guardrail" to be considered relates to whether the AI tool is being used as anticipated by the designer of that tool. There is nothing to assure that an AI tool will perform as anticipated, if deployed in a manner markedly different from that for which the tool was designed.

Humans are inherently "wired" to learn more effectively from "stories" than from raw data or data summaries. Generative AI can compose patient narratives into appealing stories that not only convey the necessary information while doing so in a compelling manner that attracts the attention of the reader. However, care must be taken that the AI tool "learns" from correct data.

Another of the chief challenges of Generative AI is the speed at which its capabilities are developing, which is clearly exceeding the rate at which regulations to provide reasonable "safeguards" can be enacted. The interplay between advances in generative AI and the regulation of its use and output will certainly be one of the more vexing challenges of the coming decades.

GENERATIVE AI IN EMERGENCY MEDICINE: NOW AND IN THE FUTURE

Generative AI is already beginning to enhance the workflows and workplaces of emergency medicine physicians who have gained access to Generative AI tools, and more is promised for physicians and the emergency departments (EDs) in which they work, for the future.

One recent development is in weapons screening. EDs are locations where "high stakes" decisions must be made, where some patients present with non-survivable illnesses or injuries, and where patients with intoxications or decompensated mental illnesses present for care. These factors make emergency department workers among those most likely to suffer workplace violence or threats of violence. Indeed, one recent report found that in one urban emergency department, workers averaged one incident or threat of violence for every 3.7 shifts that they worked [25].

Generative AI tools have been deployed in Canada to screen emergency department (ED) patients and visitors for weapons, without the need for those screened to empty their pockets of metallic materials. Such a system was placed into service on April 15, 2025 at the London, Ontario Health Sciences Center's University Hospital, after a firearms shooting in an adjacent parking lot spurred a drive to enable a safer workplace and treatment space for all. During the first day and a half of operation, seven knives were confiscated from ED patients and visitors. The Windsor, Ontario Regional Hospital has had an AI-based system in place since October of 2023. At first, approximately 20 knives were confiscated per day at that ED. Now, that number has fallen to about six per day. These AI-enhanced system reliably discriminated potential weapons (chiefly knives in Canada) from other metallic objects such as keys, mobile phones or pocket change. The system sounds an alarm when it concludes

a weapon may be present, and its performance has been highly reliable [26].

Other ED operations tools have been developed. A tool from "Mednition" called "KATE" has already been documented to improve the speed and accuracy of "Emergency Severity Index" (ESI) triage decisions, compared to ESI assignments derived from nursing-performed triage [27]. Britain's National Health Service has created an AI-informed tool that was deployed at its Kettering Hospital and which improved inpatient bed allocation and management processes, toward ameliorating the "gridlock" that plagues ED throughput due to an inability to admit to-be-admitted patients into their inpatient hospital beds [28]. Attempts are being made to leverage AI to model ED staffing needs to accommodate for combined influences of historical staffing need trends and real-time patient data, but it appears that these efforts have not yet achieved sufficient refinement to enable replacement of humans for staff scheduling functions [29].

Toward enhanced diagnosis, "Smart technology" is advancing at a rapid pace. One interesting development that could enhance emergency physicians' performance of a seldom-utilized skill is a hand-held eye fundus camera, that can provide high quality images without the need to dilate the pupil. But, even more impressively, its AI-enhanced functionality can detect pathologic changes such as diabetic retinopathy in seven seconds or less [30].

Also, AI-enhanced software has proven useful in helping emergency physicians reliably acquire highly useful ultrasound images with minimal training. Studies of image quality obtained by inexperienced ultrasonographer-emergency physicians, as reported by a team led by Cristiana Baloescu, MD, MPH, an assistant professor of emergency medicine at Yale University School of Medicine, have shown that after just a short training session, novices with no or minimal prior experience at obtaining trans-thoracic echocardiograms, if provided AI guidance, can produce "expert-level" lung ultrasound images [31].

One needs only to think of the numerous patients with dysnpnea that are managed by emergency physicians, when the dilemma is whether the dyspnea is due to a COPD exacerbation or asthma (which can cause air trapping in the lungs) or by a processes that causes fluid acquisition in the lungs, such as pneumonia or acute decompensated cardiac insufficiency, to visualize the usefulness of this advance. Fluid-overloaded lungs will typically exhibit "B-lines" that align in an axis vertical to the ultrasound probe. In contrast, lungs with air trapping from COPD, without concomitant cardiac insufficiency, will exhibit "A-lines" that represent reflections of the ultrasound wave by the pleura, and are oriented parallel to the body surface. At 1:40 into 4:20 video of Jacob Avila "Ultrasound of Pulmonary Edema", a clear differentiation between "A-lines" and "B-lines" is presented with exceptional clarity [32].

In the patient management front, at least two exciting developments are unfolding. One field of inquiry involves predicting patients at risk of sepsis or other causes of "clinical deterioration", and the other concerns a new means to accurately monitor patients in shock states for their cardiac output.

As regards sepsis, Suchi Saria, the director of the Machine Learning and Healthcare Lab at Johns Hopkins University, along with her team, have produced an effective, AI-derived sepsis early warning score, the "Targeted Real-time Early Warning System ("TREWS"). They have produced compelling data in large prospective studies, enrolling over 600,000 patients, in which they learned that caregivers learned to trust TREWS alerts, and subsequently, obtained measurable reductions in mortality from sepsis. The TREWS algorithm predicts sepsis earlier and more accurately than other warning scores [33].

This is not to say that all AI-derived prediction tools outperform human-created ones. Dana Edelson and colleagues at the Yale University School of Medicine found that the British National Health Service's "National Early Warning Score" or "NEWS" outperformed the AI-derived "Epic Clinical Deterioration Index" for predicting patients' physical deterioration in an Intensive Care Unit (ICU) setting [34].

The obtaining of accurate cardiac output data would be invaluable when sorting shock states. "Distributive" shock states, such as septic shock, typically are accompanied by high cardiac contractility and cardiac output. "Cardiogenic" shock from decompensated cardiac insufficiency has low cardiac outputs and low ejection fractions. Shock that is "Hemorrhagic" or "Hypovolemic", as typically accompanies trauma or internal bleeding, is characterized by low cardiac output despite high contractility. "Obstructive" shock states such as occurs with pulmonary emboli and tension pneumothorax tend to cause right ventricular overload and low cardiac output. Ultrasound machine manufacturers have created models that can grade the quality of a cardiac ultrasound and suggest that the ultrasound probe be moved if a low-quality image is being obtained. Once a high-quality image is obtained, differentiation of shock states is facilitated. One of the first marketed example of these appears to be the "Vivid" system produced and marketed by General Electric. The reader can obtain the most up-to-date information about this system's capabilities by accessing the product web site [35]. Other manufacturers can be anticipated to soon enter this market, if they have not already.

No matter which manufacturer's hardware is utilized, numerous manufacturers are working to develop machines that can leverage the fact that the left ventricular outflow tract approximates a cylinder. The diameter of the cylinder can be obtained in an apical five-chamber view of the heart. The motion of the tricuspid valve between end-diastole and end-systole will approximate the height of the cylinder of blood ejected per beat. Thus, with the diameter and the height of the cylinder determined, the machine can estimate stroke volume, and this times heart rate will yield cardiac output. There is no longer any need to apply the Fick equation to derive cardiac output invasively!

For medical record documentation, AI tools are being developed with the goal of becoming able to produce attractive story-like narratives obtained after recording real-time voice data from physician-patient encounters. Such software would be required to understand both the clinician and the patient to function usefully, and AI enhances this ability. Such an advance promises significant time-savings for the clinician, and in an era when physician supply is falling short of physician demand, any tool that could enable a physician to evaluate more patients per day without impinging on post-work time for documentation obligations. Thus, such a system could enhance patient access to care while providing a partial remedy for physician "burnout" that derives from documentation obligations.

For a recent review of how non-emergency physicians are creatively using AI-driven tools to enhance their diagnosis of patients and documentation of care, a review published in April of 2025 is available [36]. It can be readily anticipated that many of the clever approaches of our non-emergency medicine colleagues will soon become adopted and evaluated within our specialty.

A USEFUL AI RESOURCE

As noted above, AI is advancing at an exceptional rate, and no one can keep up on all developments in the field, even if one limits one's focus to developments relevant to medicine in general and emergency medicine in particular. The Journal of the American Medical Association and its family of journals has recently created "JAMA-AI". It was launched after the JAMA Editor-in-Chief Kirsten Bibbins-Domingo or colleagues interviewed numerous "thought leaders" in AI as regards medical issues, with the abridged versions of these interviews appearing periodically in the JAMA beginning in November of 2023.

A CAUTIONARY NOTE

Most AI in general use has learned from open-source data that may or may not be particularly accurate. Before implementing AI in one's practice, one should be sure that the AI tool was "trained" on accurate and reliable data. Tools that are trained on the Internet risk inaccuracy, because the Internet, "writ large", can be thought of as the world's largest graffiti board. One should insist on using tools that have been properly trained on appropriate and applicable data sets. This matter is explored further by data scientist Nigham H Shah [37].

SUMMARY

As stated by prior AMA President Jesse Ehrenfeld, MD, "It is clear to me that AI will never replace physicians – but physicians who use AI will replace those who don't" [3].

It is hoped that this manuscript will provide the reader with an enhanced understanding of the "Generations" of AI, and what each "generation" has brought to medical care, so that they are equipped to incorporate AI knowledgeably into their work flows.

In addition, by providing an overview of recent and unfolding developments that show how AI, especially generative AI, is enhancing medical care in general and for emergency medicine in particular, it is hoped that the reader will become a knowledgeable and confident adopter of these technologies, upon their dissemination and documentation of effectiveness.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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Three different appendicitis diagnostic scores in pediatric emergency department

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ABSTRACT

Aim: Acute abdominal pain is a frequent pediatric emergency department (PED) complaint, with appendicitis as the top surgical cause. Diagnosis is challenging, especially in young children with vague symptoms. In this study we aimed to examine the alignment of Alvarado, PAS scores, and ultrasound with final appendicitis diagnoses.

Materials and Methods: We conducted a retrospective single-center study of children aged 1–17 presenting with abdominal pain to our PED in September 2018. Alvarado, PAS, and HAS scores were calculated, and their diagnostic accuracy was assessed using AUC analysis.

Results: Of 254 children (52.8% female, mean age 9.26 ± 4.64 years), 53 were diagnosed with appendicitis. Blood tests were performed in ~50%, and 95% had an abdominal US. Appendicitis was more common in older children and significantly associated with leukocytosis, neutrophilia, and CRP >60 mg/L. The Alvarado score showed a significant association ($p < 0.001$) and highest AUC (0.612), while PAS and HAS had slightly lower AUCs and were not statistically significant.

Conclusions: Among clinical scoring systems, the Alvarado Score demonstrated the strongest, though moderate, predictive value for diagnosing appendicitis in this population.

KEY WORDS

appendicitis, scores, pediatric, Emergency Medicine, Alvarado, PAS

INTRODUCTION

Acute abdominal pain is one of the most common reasons for pediatric visits to the Pediatric Emergency Department (PED), with appendicitis being the leading surgical cause [1]. Up to 38% of school-aged children report weekly abdominal pain [2], and it accounts for 10% of PED visits [3]. Due to its nonspecific nature, the causes vary widely depending on age, underlying conditions, and communication ability [1]. Krenke et al. [4] found that 50% of children with cough, fever, or dyspnea also had abdominal pain, emphasizing the need for thorough evaluation.

Appendicitis affects about 83 per 100,000 children annually and is the fifth most common reason for pediatric hospitalization in the US. [5, 6]. Diagnosis is difficult, especially in young children, due to vague symptoms and reliance on caregiver-reported history [7]. Up to 44% present atypically [8, 9], leading to unnecessary admissions and a 4-17% rate of negative appendectomies [8, 10, 11]. Missed diagnoses are also rising, resulting in increased complications, more extended hospital stays, and higher healthcare costs [12, 13].

Typical appendicitis signs – migratory pain, anorexia, nausea, and vomiting – are often absent in children under five [14]. Blood tests like White Blood Cell (WBC) count, Absolute Neutrophil Count (ANC), and C-Reactive Protein (CRP) are helpful but not specific [6]. Anandalwar et al. [15] found that combining normal ultrasound (US), WBC $<10.0 \times 10^9$/L, and ANC <65% reduced false negatives to 4.2%. Ultrasound is widely used, but Kashtan et al. [16] reported 44.7% of scans were nondiagnostic, with 13.9% still having appendicitis, the accuracy highly depends on operator skills.

To improve diagnostic accuracy and reduce missed cases, scores like Alvarado and PAS are used, especially in smaller or regional hospitals. In this study we aimed to analyse how the final diagnosis of appendicitis aligns with such appendicitis scores as Alvarado, PAS, and US in our PED.

MATERIALS AND METHODS

STUDY DESIGN AND STUDY POPULATION

A retrospective single-center study was conducted at the Lithuanian University of Health Sciences Hospital Kauno Klinikos. Data of all children from 1-17 years old who visited the PED in September 2018 with abdominal pain were collected. Patients with chronic diseases (oncologic or/and hematologic diseases, autoimmune gastroenteric diseases, immunodeficiency) or psychiatric illnesses, toxic poisoning, and traumatic causes of abdominal pain were excluded from the study.

DATA COLLECTION

Demographic data (age, gender), past medical history, clinical history (complaints and duration of symptoms, vital signs), physical signs (location and characteristic of pain, associated factors, such as nausea/vomiting, loss of appetite, fever), laboratory results (complete blood count (CBC) (leukocytes, ANC), CRP) specific abdominal US results, and outcomes, such as hospitalization, observation were collected from the hospital electronic medical record system. CBC and CRP were assessed according to the age-specific norms [17].

APPENDICITIS SCORING SYSTEM

Based on literature review and preliminary data analysis, three different appendicitis scoring systems were selected for evaluation in all children: the Alvarado Score, the Pediatric Appendicitis Score (PAS) and the Heidelberg Appendicitis Score (HAS) [18]. The PAS and Alvarado scores are both eight-item tools developed to predict appendicitis in pediatric patients. The HAS was included as it is the only scoring system that incorporates US findings. The full list of clinical parameters included in each scoring system is listed in Table 1.

STATISTICAL ANALYSIS

Data were collected using MS Excel software, and statistical analysis was conducted with SPSS 28.0 for Windows. Qualitative data are presented as counts (n) and percentages (%). When evaluating the correlation between the time from symptom onset and various clinical indicators, children were categorized into four groups: <24 hours (group 1), ≥24 hours (group 2). To assess age-related differences in clinical and diagnostic indicators, patients were categorized into three age groups: 0–4 years (group 1), 5–9 years (group 2), ≥10 years (group 3). For outcome-based comparisons, children were grouped according to their clinical disposition: discharged home (group 1), hospitalized (group 2), observed and discharged home (group 3), observed and hospitalized (group 4). The Shapiro–Wilk test was used to assess the normality of data distribution. Continuous variables are expressed as means ± standard deviation (SD) for normally distributed variables and as medians with interquartile range (IQR). Group comparisons were performed using the independent samples t-test for normally distributed data and the Mann–Whitney U test for non-parametric data. Categorical variables were compared using the chi-square or Pearson's chi-square test was used to assess differences between groups. Logistic regression models were applied to evaluate the strength of associations between variables, with 95% confidence intervals (95% CI) calculated for each. For further logistic regression analysis, the age group 1 and group 2 were pooled together, and the data were stratified according to 2 age groups as following: ≥10 years of age (group 1) and younger (group 2). The diagnostic performance of the appendicitis scoring systems was assessed using receiver operating characteristic (ROC) curve analysis. The area under the ROC curve (AUC) was used to determine the sensitivity and specificity of each scoring system. A p-value <0.05 was considered statistically significant.

ETHICAL CONSENT

As the study was retrospective and only aggregated data was submitted for further analysis, additional ethical approval was not required.

Table 1. Different scoring systems for diagnosing appendicitis including the different weighing factors for each score

	Alvarado	PAS	HAS
RLQ tenderness	2	2	1
Peritoneal irritation	1	-	1
WBC (>12 x109/L)	2	1	-
Neutrophilia (>7.9 x109/L)	1	1	-
US demonstrating appendicitis	-	-	1
Cough / hopping tenderness	-	2	-
Nausea / vomiting	1	1	-
Anorexia / urine acetone	1	1	-
Migration of pain	1	1	-
Continues pain	-	-	1
Fever	1	1	-
Positive score	**5/10**	**6/10**	**3/4**

PAS – Pediatric Appendicitis Score, WBC – white blood cells, °C – Celsius degree, RLQ – right lower quadrant, HAS – Heidelberg Appendicitis Score, US – ultrasound

Source: Own materials

Table 2. General characteristics of the study participants

Number of patients included, n		**254**	
Gender (female), n (%)		134 (52.8)	
Mean age, ±SD		9.24 ± 4.64	
Age groups, n (%)	0-4 y.o.*	47 (18.5)	137 (54
	5-9 y.o.*	90 (35.5)	
	≥10 y.o.	117 (46.0)	
Duration of symptoms, n (%)	<24 h	160 (63)	
	≥24 h	94 (37)	
Symptoms, n (%)	Abdominal pain in right quadrant	85 (27.3)	
	Fever	106 (42.0)	
	Mean temperature ± SD	37.29 ± 0.87	
	Anorexia	21 (8.3)	
	Nausea/vomiting	107 (42.1)	
	Pain migration to right quadrant	20 (8.0)	
	Respiratory symptoms	7 (2.76)	
Abdominal palpation**	Pain location: LRQ LLQ lower umbilical epigastric subcostal umbilical whole abdomen	 77 (30.3) 26 (10.2) 33 (13.0) 31 (12.2) 21 (8.3) 24 (9.4) 40 (15.7)	
	Peritoneal irritation	31 (12.2)	
	Abdominal muscular rigidity	31 (12.2)	
Diagnosis groups**	Appendicitis	53 (20.9)	
	Gastrointestinal pathology	170 (66.9)	
	Other abdominal surgical	5 (2.0)	
	Other (including respiratory, etc.)	26 (10.2)	
Tests in PED	CBC**	123 (48.4)	
	Leu (mean; ±SD)	10.2 ± 3.7	
	Leukocytosis**	24 (9.4)	
	Neutrophils (mean, ±SD)	6.9 ± 3.7	
	Neutrophilia**	39 (15.4)	
	CRP**	125 (49.2)	
	CRP (mean, 95% CI)	21.9 (15.3-28.4)	
	Abdominal US**	241 (95.0)	
Outcome**	Discharged	134 (53.0)	
	Hospitalized	75 (30.0)	
	24h observation, hospitalized	31 (12.0)	
	24h observation, discharged	13 (5.0)	
	CRP**	125 (49.2)	
	CRP (mean, 95% CI)	21.9 (15.3-28.4)	

Abdominal US**	241 (95.0)
Discharged	134 (53.0)
Hospitalized	75 (30.0)
24h observation, hospitalized	31 (12.0)
24h observation, discharged	13 (5.0)

PED – pediatric emergency department; n – total number of participants; CI – confidence intervals; y.o. – years old; CBC – complete blood count; CRP – C-reactive protein; US – ultrasound; h – hour; SD – standard deviation, IQR – interquartile range, LRQ – lower right quadrant, LLQ – lower left quadrant. *identified data which was pooled for more thorough analysis; **n (%)

Source: Own materials

Table 3. Factors associated with hospitalisation vs. discharge home

	Hospitalized	Discharged	p value
Decreased appetite*	8/89 (9.0)	13/164 (7.9)	0.770
Abdominal pain migration*	12/84 (14.2)	8/165 (4.8)	0.015
Nausea/vomiting*	37/89 (41.6)	70/163 (42.9)	0.957
Duration of pain (up to 24 h) *	54/89 (60.7)	106/165 (64.2)	0.407
Fever (<38°C) *	63/89 (70.8)	135/165 (81.8)	0.151
Peritoneal irritation*	23/89 (25.8)	8/165 (4.8)	<0.001

n – total number of participants; % – percentage; p – probability; °C – degree Celsius; *n (%)

Source: Own materials

Table 4. Multivariate analysis of factors associated with hospitalisation

	OR	95% CI	p value	OR*	95% CI	p value
Abdominal pain migration**	3.06	1.2-7.79	<0.001	1.41	0.45-4.46	0.561
Peritoneal irritation**	9.17	3.1-26.9	<0.001	7.98	2.62-24.28	<0.001

n – number; % – percentage; OR – odds ratio; CI – confidence interval; p – probability; *adjusted to age; **n (%)

Source: Own materials

RESULTS

GENERAL CHARACTERISTICS OF THE STUDY

A total of 254 children with abdominal pain were included in the study. 52.8% were female. The mean age was 9.26 ± 4.64 years, with the largest group of children aged ≥10 years (46%). Majority (63%) of the patients presented to the PED within 24h from the onset of symptom. Most commonly, children complained about lower right quadrant (LRQ) abdominal pain, often accompanied by nausea/vomiting and fever. Over half of the patients were discharged after the evaluation. The clinical diagnosis of appendicitis was made in 53 patients (20.9%), while the remaining cases were attributed to other gastrointestinal causes: constipation, mesadenitis, gastritis, gastroenteritis, or other pathologies: ovarian cysts, urinary or respiratory tract infections. Laboratory investigations were performed in nearly half of the patients, with CBC in 48.4% and CRP testing in 49.2%. Leukocytosis was observed in 9.4% and neutrophilia in 15.4% of patients. The median CRP level was 21.9 mg/L (95% CI 15.3-28.4). Abdominal US was performed in 95.0% of patients.

Regarding outcomes, 53.0% of patients were discharged home, 30.0% required hospitalization, and 17.0% underwent 24-hour observation, with 12.0% subsequently hospitalized and 5.0% discharged. Additional descriptive statistics are provided in Table 2.

ASSOCIATIONS BETWEEN CLINICAL FEATURES AND PATIENT CHARACTERISTICS

There was no statistically significant difference in time of arrival between the age groups; the majority arrived <24h of the onset of abdominal pain. More older children were diagnosed with appendicitis (33 *vs.* 20, p=0.008). Nearly half of the patients in all age groups presented with nausea and vomiting. Older patients noted focal pain (right abdominal) while younger patients presented with more diffuse abdominal pain (p<0.001). Older children complained of abdominal pain migration significantly more frequently compared to younger ones (16/117 *vs.* 4/137, respectively, p=0.002), lack of this symptom was associated with other gastrointestinal diseases than appendicitis in both groups (odds ratio (OR) 2.17, 95% CI 1.14-4.13; p=0.017). None of the symptoms differ between female and male. On abdominal examination, older children were more likely to present with abdominal irritation (OR 13; 95% CI 3.6-51.6).

OUTCOME MEASURES

There was no significant difference in hospitalization rates based on age groups or symptoms (fever, nausea/vomiting, or decreased appetite), only patients with reported abdominal pain migration (40% *vs.* 60%, p=0.015), peritoneal irritation (25.8% *vs.* 74.2%, p<0.001) were hospitalized more frequently. More information provided in Table 3. In the multivariate analysis, only children with abdominal pain migration were 3 times more likely and with peritoneal irritation were 9 times more likely to be hospitalized (95% 12-7.79; p<0.001; OR (adjusted to age) 1.41. 95% CI 0.45-4.46; p=0.561; 95% CI 3.13-26,92; p <0.001; OR (adjusted to age) 7.97, 95% CI 2.62-24.28; p<0.001, respectively). Results shown in Table 4. Interestingly, we found that girls with appendicitis were hospitalised more often, compared to male patients (63.3% vs 36.7%, p=0.029).

CLINICAL AND DIAGNOSTIC PARAMETERS IN APPENDICITIS AND OTHER CAUSES OF ABDOMINAL PAIN

There were no statistically significant differences between the appendicitis and non-appendicitis groups in terms of nausea/vomiting (37.7% *vs.* 43.7%, p=0.504), anorexia (7.5% *vs.* 8.5%, p=0.823), fever (28.8% *vs.* 20.0%, p=0.210), or symptom duration (p=0.834). Similarly, pain migration to the RLQ (9.4% *vs.* 7.5%, p = 0.636) and abdominal muscular rigidity (20.8% *vs.* 10.0%, p=0.064) did not significantly differ between groups. However, peritoneal irritation was significantly more common in children with appendicitis (30.2% *vs.* 7.5%, p < 0.001), as were elevated inflammatory markers. Children with appendicitis had significantly higher rates of leukocytosis (WBC >12 × 10^9/L; 15.1% *vs.* 8.0%, p=0.008), neutrophilia (>7.9 × 10^9/L; 22.6% *vs.* 13.4%, p=0.009), and CRP >60 mg/L (7.5% *vs.* 5.5%, p=0.011). Ultrasound findings indicating an enlarged appendix (≥6 mm) did not significantly differ between groups (p=0.388). Other results shown in Table 5.

DIAGNOSTIC PERFORMANCE OF APPENDICITIS SCORING SYSTEMS

The diagnostic utility of three appendicitis scoring systems – Alvarado Score, PAS, and HAS – was evaluated in 254 children (252 for HAS due to missing data). In the Alvarado Score group, 44 children had a positive score (≥5 points), which is considered indicative of higher likelihood of appendicitis. Among these, 25 patients were confirmed to have appendicitis, yielding a statistically significant association (p<0.001). The diagnostic accuracy of the Alvarado Score, as assessed by ROC AUC – 0.612 (95% CI 0.521–0.702), indicating modest discriminative ability.

For the PAS, 15 children had a score of ≥5, with appendicitis confirmed in 11 of these cases. This association was not statistically significant (p=0.133). The AUC – 0.614 (95% CI 0.52–0.71), also reflecting limited diagnostic performance

In the case of the HAS, 5 children scored ≥3 points, and 4 of them were diagnosed with appendicitis. However, the association was not statistically significant (p=0.725). The AUC was 0.599 (95% CI 0.52–0.68), suggesting similarly limited discriminatory power. A detailed summary of these results is presented in Table 6.

Table 5. Signs and symptoms used in scores to diagnose appendicitis

Symptoms		Not appendicitis	Appendicitis	p value
Pain migration to LRQ*		15 (7.5)	5 (9.4)	0.636
Nausea/vomiting*		87 (43.7)	20 (37.7)	0.504
Anorexia*		17 (8.5)	4 (7.5)	0.823
Duration of symptoms*	<24 h	127 (63.8)	33 (62.3)	0.834 p value is for all 4 groups
	>24 h	72 (36.2)	20 (37.7)	
Abdominal muscular rigidity*		20 (10.0)	11 (20.8)	0.064
Peritoneal irritation*		15 (7.5)	16 (30.2)	<0.001
Fever >38°C*		41 (20.0)	15 (28.8)	0.210
WBC (>12 x109/L)*		16 (8.0)	8 (15.1)	0.008
Neutrophilia (>7.9 x109/L)*		27 (13.4)	12 (22.6)	0.009
CRP >60 mg/L*		11 (5.5)	4 (7.5)	0.011
US appendix ≥6 mm*		25 (73.5)	9 (26.5)	0.388

n – number; % – percentage; p – probability; LRQ – lower right quadrant, h – hour, ℃ – degree Celsius; *n (%)

Source: Own materials

Table 6. Positive score in different scales: appendicitis *vs.* other cause

	Alvarado score n=254	p value	PAS n=254	p value	HAS n=252	p value
Positive score* [n]	44	-	17	-	5	-
Appendicitis diagnosis; n	25	<0.001	11	0.133	4	0.725
Other; n	19		6		1	
AUC (95% CI)	0.612 (0.52-0.70)	0.016	0.614 (0.52-0.71)	0.017	0.599 (0.52-0.68)	0.014

*positive score according to Alvarado is 5/10; PAS 6/10; HAS ¾; p – probability; n – number; PAS – Pediatric Appendicitis Score; HAS – Heidelberg Appendicitis Score, AUC – area under the curve; % – percentage, CI – confidence interval

Source: Own materials

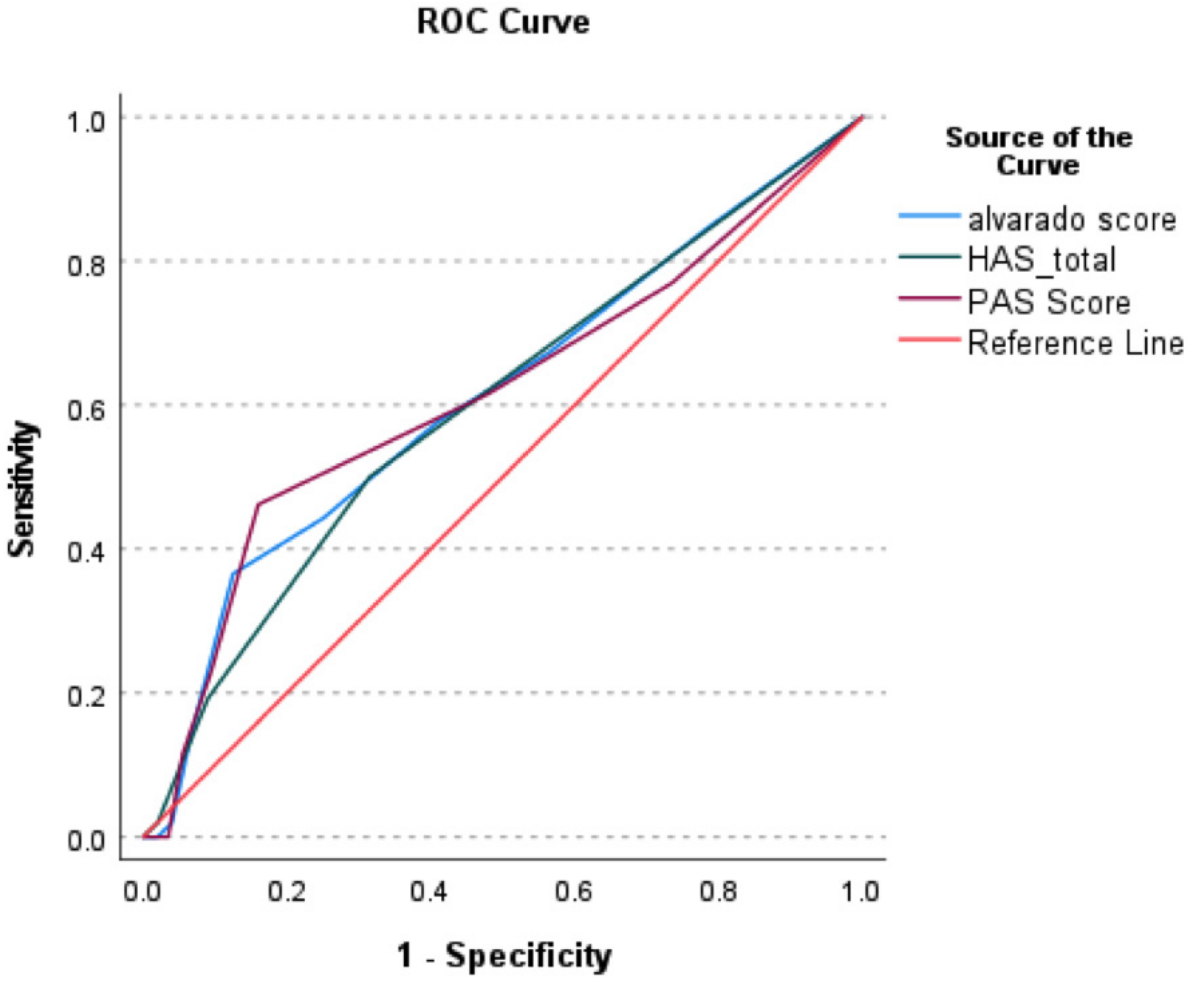

Fig. 1. ROC of Alvarado, PAS, and HAS scores in patients with suspected appendicitis

Source: Own materials

The ROC curves for the Alvarado score, PAS, and HAS are depicted in Figure 1.

DISCUSSION

In this study, we evaluated the clinical presentation, diagnostic investigations, and performance of three appendicitis scoring systems – Alvarado Score, PAS and HAS – in a cohort of 254 pediatric patients presenting with abdominal pain to a PED. Appendicitis was confirmed in 20.9% of cases, with the remainder attributed to various gastrointestinal and non-abdominal causes. Our findings offer important insights into the utility and limitations of clinical and laboratory parameters, as well as existing scoring tools, in the diagnostic workup of pediatric appendicitis.

Consistent with previous studies, the most common symptoms in our cohort were RLQ pain, nausea/vomiting, and fever, with peritoneal signs and focal tenderness more frequently observed in older children [12]. While classical features such as pain migration and anorexia were reported, their frequency was relatively low and did not significantly differentiate appendicitis from other causes. This aligns with findings from Woo Song et al. [19], who demonstrated that appendicitis in preschool-aged children often presents with nonspecific symptoms, shows rapid clinical progression, and is associated with a higher rate of complications. Lounis et al. [20] further emphasized the impact of age, reporting that younger children tend to experience longer symptom durations, more pronounced systemic responses, and increased rates of perforation – primarily due to diagnostic delays. In our study, no significant association was found between patient age and time to diagnosis or symptom specificity. This discrepancy may be attributed to our inclusion of a broader pediatric population (up to 18 years of age), without exclusive analysis of preschool-aged children. Interestingly, the majority of children presented within 24 hours of symptom onset, yet time of arrival was not significantly associated with final diagnosis or hospitalization, suggesting that symptom duration alone is not a reliable predictor of appendicitis in children. Our observation that older children more frequently exhibited pain migration and focal tenderness supports prior evidence that diagnostic clarity improves with age due to better symptom localization and communication [21].

Our data showed that peritoneal irritation was the most specific clinical sign for appendicitis, present in 30.2% of appendicitis cases compared to 7.5% in others ($p<0.001$). Additionally, elevated inflammatory markers – leucocytosis, neutrophilia, and CRP >60 mg/L – were significantly associated with appendicitis. These findings are consistent with prior research supporting the combined diagnostic value of laboratory markers and clinical signs [22, 23]. Furthermore, Lan et al. [24] investigated the role of leukocytes, neutrophil count, and CRP levels in distinguishing between complicated and uncomplicated appendicitis cases. Their findings showed that these inflammatory markers, particularly when used in combination, exhibited increased sensitivity for identifying complicated cases. Reismann et al. [25] developed and validated a composite biomarker signature, it outperformed traditional single-marker assessments, such as CRP, WBC count, and ANC. Notably, their study also found that US parameters – specifically appendiceal diameter-lacked significant predictive capacity in differentiating disease severity.

In terms of diagnostic tools, in our study, abdominal US was performed in 95% of cases, yet an appendix ≥6 mm was not significantly more common among those diagnosed with appendicitis ($p=0.388$). Non-visualization rates can be high, with one study reporting a 73% rate of cases [26]. Various studies have shown moderate sensitivity (62.7-96.4%) and specificity (79.1-96.0%) for US in diagnosing appendicitis [26, 27]. Factors affecting visualization include patient age, weight, and the presence of specific sonographic findings. While the US remains a first-line modality due to its safety and accessibility, obesity, particularly in males, increases the likelihood of inaccurate US results [28]. Despite these limitations, US remains valuable due to its safety and accessibility.

We assessed the diagnostic performance of three commonly used scoring systems. The Alvarado Score showed a statistically significant association with appendicitis ($p<0.001$) and the highest AUC (0.612, 95% CI: 0.52-0.70) but still demonstrated limited discriminative ability. The PAS and HAS had slightly lower AUCs (0.614 and 0.599, respectively) and did not show statistically significant associations with confirmed appendicitis. These modest AUC values suggest that while such scores can aid in decision-making, they should not be used in isolation. A meta-analysis by Benabbas et al. [29] reported similar diagnostic limitations of both the Alvarado Score and PAS, especially in younger children. In a study by Woo Song et al. [19], clinical scoring systems, such as the PAS and modified Alvarado Score, showed lower scores in appendicitis cases in preschool children compared to school-aged children. Rassi et al. [30] reported that the performance of the Alvarado Scores was suboptimal in children under 4 years of age, with the AUC of 0.73, while PAS demonstrated even lower AUC of 0.69 in the younger children. Interestingly, some studies already showed that some new scores – the pediatric Appendicitis Risk Calculator (pARC), appendicitis inflammatory response (AIR) – provided superior diagnostic performance compared to the PAS and Alavarado score [31, 32]. In our study, we did not evaluate the AIR score or pARC, as clinical decision-making in our institution predominantly relies on the PAS and/or Alvarado Score. We did include the HAS score in our analysis, as our results showed 95% of children received abdominal US. However, sensitivity and specificity analyses further confirmed the limited standalone performance of all three scores. At lower thresholds (≥0.5), sensitivity was high, but specificity was poor. Conversely, at higher thresholds (≥5.5 and above), specificity improved, but sensitiv-

ity dropped sharply, indicating that these tools may be better suited for ruling out rather than confirming appendicitis, depending on the clinical context. Thus, the alternative scoring systems, such as pARC and AIR score, warrant further investigation in our future studies, with the potential for integration into routine clinical practice.

Multivariate analysis revealed that peritoneal irritation was the strongest independent predictor of hospitalization (adjusted OR: 7.97, 95% CI: 2.62-24.28; p<0.001), further supporting its clinical relevance in decision-making. Notably, girls with appendicitis were hospitalized more frequently than boys (63.3% *vs.* 36.7%, p=0.029), a finding warranting further exploration regarding potential gender bias or differences in presentation. A study identified sex-based disparities in the diagnosis of appendicitis: older female patients exhibit a higher likelihood of false-positive appendicitis diagnoses [33], no significant difference in length of hospital stay (LOS) between male and female patients represented [34]. However, the study demonstrated that the presence of abscess, free fluid in the right upper quadrant on US/MRI/CT, and CRP >12mg/dl were independent predictors of prolonged hospitalization.

Our findings underscore the importance of combining clinical judgment with structured assessments. While scoring systems like Alvarado, PAS, and HAS offer guidance, their modest diagnostic performance emphasizes the need for careful interpretation in the pediatric setting. Future efforts may benefit from integrating newer biomarkers (e.g., procalcitonin, fecal calprotectin) or artificial intelligence-based decision tools to enhance diagnostic accuracy [35, 36].

CONCLUSIONS

In conclusion, our study underscores the complementary value of clinical signs and laboratory markers in diagnosing pediatric appendicitis, while also highlighting the limitations of current diagnostic tools. Although the Alvarado Score showed a statistically significant association with appendicitis, its overall power remained modest. The PAS and HAS performed similarly but lacked statistical significance. These findings emphasize that while existing scoring systems can support clinical judgment, they are insufficient as standalone diagnostic tools. Moreover, the limited utility of US – particularly when the appendix is not visualized – further supports the need for a more integrated diagnostic approach. Future research should explore alternative scoring systems and prediction rules for potential implementation in clinical practice.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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ORIGINAL ARTICLE

Crisis of homelessness and the use of psychoactive substances

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ABSTRACT

Aim: To empirically assess the relationship between homelessness and the use of psychoactive substances, with particular emphasis on the identification of the most commonly used substances and the explanation of the basic sources of financing their acquisition.

Material and methods: The study was conducted in Warsaw from December 2024 to February 2025. The research sample consisted of 50 people in the homelessness crisis (46 men and 4 women), recruited from people living on the streets, in shelters and shelters. A mixed quantitative-qualitative method was used, using the CAPI technique and a self-developed research questionnaire containing closed and open questions.

Results: The vast majority of respondents (80%) declared the use of psychoactive substances. Legal substances such as cigarettes and alcohol were the most frequently reported. The main sources of income for the purchase of substances were begging (transshipment, collection of secondary raw materials) and social assistance. Statistical analysis of the sample showed a significant correlation ($p < 0.05$) between homelessness status and substance use.

Conclusions: The results of this study support the hypothesis of a two-way relationship between addiction and homelessness, substance use may act as both a risk factor for homelessness and a coping mechanism for homelessness. The results point to the need for further in-depth research and the development of integrated interdisciplinary strategies to support people experiencing homelessness. Such strategies should include addiction treatment, social intervention and reintegration programmes.

KEY WORDS

homelessness crisis, addiction, psychoactive substances

INTRODUCTION

"The Act of 12 March 2004 on Social Assistance defines a homeless person as a person who does not live in a dwelling within the meaning of the provisions on the protection of tenants and who is not registered as a permanent residence in any dwelling, as well as a person who cannot live in his or her place of residence due to incapacity to live" [1].

Homelessness is a multifaceted and challenging phenomenon that manifests itself in various forms, from total street homelessness to sleeping in parks, staying in public buildings and using temporary shelter accommodation. This diversity, combined with the different definitions and measurement methodologies adopted in different countries, complicates the comparative analysis. Statistics often overlook people experiencing short-term homelessness, people temporarily staying with friends, living in cars, or avoiding formal support networks. Despite the difficulty of grasping the full scale of this phenomenon, one factor is clear: the lack of stable housing has a significant impact on health, life expectancy and poverty levels [2].

In the social structure, addictions are particularly prevalent among economically excluded groups, such as the unemployed and pensioners. Epidemiological data from the nationwide EZOP II survey on the prevalence of mental disorders in Poland have shown that the prevalence of disorders related to alcohol and drug use in these groups is significantly higher compared to professionally active people [3]. This suggests a strong correlation between social status and addiction risk. Poor status and homelessness, as an extreme form of economic exclusion, are at the epicenter of this risk of substance use and abuse [3, 4].

Both the political context and family of origin, as well as crises occurring in the later stages of life [4], contribute not only to an increase in alcohol consumption, regardless of socio-economic status, level of education or profession, but also to the appearance of negative consequences, including increased mortality [4]. This is another reason why it is worth including this particularly vulnerable social group in the study due to its increased vulnerability to the effects of the crisis.

A new challenge in the context of the use of psychoactive substances by homeless people is the increase in the popularity of the so-called new psychoactive substances, commonly referred to as "" or "". According to the data of the Chief Sanitary Inspector for the years 2020 – 2022, the use of these substances has increased in marginalized communities, especially in the capitals of voivodeships, where these substances are more accessible and cheaper than traditional drugs. This phe-

nomenon contributes to the increase in the number of poisonings and deaths among homeless people who do not have access to regular health care [5].

Along with the observed epidemiological trends, a wider social problem appears, homeless people addicted to alcohol and drugs are more and more often perpetrators or victims of violence and more often come into conflict with the law. Data from the report The impact of alcohol and drug problems on the safety of local communities indicate that the increase in the presence of addicts in public space correlates with an increase in the sense of danger among residents and the escalation of risky behaviour in the main urban agglomerations [6].

There are five stages of homelessness:

1. Stage I
   – Breakdown of the life plan and family breakdown;
2. Stage II – Poverty;
3. Stage III
   – Different dimensions of becoming homeless;
4. Stage IV – Adaptation to homelessness;
5. Stage V – Entrenched (chronic) homelessness [7].

At least two million people in OECD countries have been identified as experiencing homelessness [8]. In February 2024, the latest nationwide survey in Poland, conducted under the auspices of the Ministry of Family, Labour and Social Policy, identified 31,042 people in the homelessness crisis. Of these, 80% were men (24,880) and 20% were women (6,162). Minors (under 18 years of age) constituted 5% of the study group (1,524). The highest number of people experiencing homelessness was found in the Pomeranian (4,575), Silesian (4,050) and Masovian (3,452), and the fewest in Podlasie (638), Lubuskie (717) and Opolskie (767).

This indicator indicates the continuing scale of the problem, but in a broader perspective it shows a gradual decrease in the number of homeless people per capita. For comparison: in 2015, 36,161 homeless people were identified, which is about 94 people per 100 thousand inhabitants. In 2019, this number was 30,330 people, i.e. about 80 people per 100 thousand inhabitants. During the pandemic (2021), this indicator temporarily increased to about 85 people per 100 thousand, m.in due to difficult access to assistance services. Data from 2024 therefore suggest a relative stabilization of the problem of homelessness, although not to the same extent in all regions of Polish. The highest rates were recorded in the following voivodeships: Pomorskie (approx. 195 people per 100 thousand), Śląskie (approx. 88 people per 100 thousand) and Mazowieckie (approx. 63 people per 100 thousand), which indicates a clear regional differentiation.

The most frequently cited reasons were: alcohol addiction – 19%, family conflicts – 17%, evictions – 11%, [9]

Research shows that homelessness significantly increases the risk of co-occurrence of mental disorders and addictions, creating a vicious circle that is difficult to break without comprehensive, multifaceted support. People experiencing homelessness are at increased risk of depression, anxiety disorders, and post-traumatic stress disorder. These conditions often intensify in response to chronic stress and traumatic experiences, leading to increased alcohol and drug consumption as a way to manage mental pain [10].

In public discourse, homelessness is often equated with addiction to alcohol, drugs or tobacco. The main objective of the study was to check whether the homelessness crisis is closely related to the use of psychoactive substances. In particular, this included determining which substances were most commonly used by the study participants, the frequency of their use, and the sources of funding for these substances.

MATERIAL AND METHODS

The survey was conducted among people experiencing homelessness in Warsaw in the period from December 2024 to February 2025. The research has been accredited by the Bioethics Committee of the Medical University of Warsaw and has been conducted in accordance with ethical principles.

The research sample consisted of 50 respondents (46 men and 4 women). Participants were divided by age into the following categories: under 30 years old, 30-38, 39-48, 49-58, 59-68 years old and over 68 years old, as well as according to the duration of homelessness: less than 1 year, 1-3 years old, 3-5 years old and more than 5 years old. The studied society was diverse in terms of life situation and personal history. Among the participants were people who lived on the streets, stayed in shelters and dormitories, or used hospice care for the homeless.

The selection of the studied group was well thought out. The data was collected using a proprietary questionnaire that included both closed and open questions about the causes of homelessness, substance use and sources of income. The study also asked about the frequency and types of substances used, as well as the financial resources for their acquisition. Participation was anonymous and voluntary. Before conducting interviews, all respondents were informed of the purpose of the study and assured of confidentiality. The survey was conducted using the CAPI method, in which the interviewer personally asked questions to the respondent, and the answers were recorded directly on an electronic device.

The questions were asked directly, without euphemisms, so that they were as understandable as possible for the respondent. By answering the question, the respondent could indicate several substances they use, determine the frequency of their use using time intervals, as well as choose a source of income from among those articulated by the interviewer or provide an answer. A significant part of the respondents lived in certain areas of Warsaw, m.in. Central Station, Western Railway Station, Poniatowski Bridge, Old Town and metro stations. Thanks to the cooperation of such institutions as the Holy Cross Hospice for Homeless Men in Mokotów and the Camillian Mission of the Social Welfare Shelter for Homeless Men, scientists have also managed to

reach people staying in these facilities. The inclusion criteria required participants to be currently experiencing homelessness and to be willing to take part in the survey. The data was analysed for demographic variables, including gender, age and duration of homelessness. The statistical analysis was carried out using SPSS software, in which the Pearson correlation coefficient was used to assess the association between homelessness and substance use. Responses to open-ended questions were subjected to qualitative analysis to identify recurring patterns and themes.

RESULTS

A total of 50 people experiencing homelessness took part in the study, including 46 men (92%) and 4 women (8%). The analysis revealed diverse patterns of substance use and sources of income to meet everyday needs, which vary by age and gender (Table 1-2).

The most commonly reported frequency of substance use was daily use. Some individuals have reported using the substance depending on their financial means, indicating significant economic conditions. Psychoactive substances were also more often used by people who cited eviction or family conflicts as the reason for their homelessness (Fig. 1).

Respondents often gave more than one reason, suggesting the complex nature of the homelessness experience. Answers such as illness, loss of job, bankruptcy of the company or inability to take up employment appeared only five times (Fig. 2).

Other respondents, when asked about their source of income, answered "no income".

The analysis showed strong correlations between the source of income and the substances used ($p < 0.05$). People who lived off hoarding were more likely to report their consumption of alcohol, cigarettes, and even hard drugs such as cocaine or heroin. People using benefits most often indicated cigarettes and alcohol. Respondents using substances declared spending primarily on medicines, food and clothing. Among non-food users, spending was most often limited to food and clothing. Analysis of the relationship between variables showed correlations between addiction as a cause of homelessness and daily use of psychoactive substances (Fig. 3).

Analysis of the data shows that one of the clearest signs of the link between the homelessness crisis and substance use is how people in crisis manage their incomes. The correlation between the allocation of funds to stimulants and their actual use reached the value of $r = 0.36$, which indicates a moderately positive relationship.

DISCUSSION

USE OF PSYCHOACTIVE SUBSTANCES BY PEOPLE EXPERIENCING HOMELESSNESS

The main objective of the study was to determine whether there is a link between homelessness and substance use. In the analysed sample, consisting mainly of men (92%, i.e. 46 out of 50 people), a significant number of respondents reported contact with psychoactive substances. The demographic structure of the sample corresponds to national trends – as indicated by the Ministry of Family, Labour and Social Policy (2024), men make up over 80% of people experiencing homelessness [9].

Respondents pointed to various substances – both legal, such as cigarettes and alcohol, and illegal, such as cocaine or heroin. The data show that the most commonly used substances were: cigarettes, alcohol, cocaine

These substances are not only present in the lives of people affected by homelessness. In many difficult situations, even for the average person, alcohol or other psychoactive substances are a kind of escape from everyday life. They help fill an emotional void, regulate emotions, or find themselves in a new social group [11].

Emilia Truskołaska's publication "Black Aspects of Homelessness" puts forward an important thesis that alcohol plays a role in the integration of the homeless community. The use of psychoactive substances, especially alcohol, serves not only to escape from suffering, but also to have an adaptation mechanism, a ritual that gives a sense of belonging to a group and a temporary sense of security. For many people experiencing homelessness, life "on the streets" becomes an everyday life governed by their own norms and rules, in which alcohol helps alleviate physical suffering (cold, hunger), as well as mental pain (a sense of rejection, hopelessness). Unfortunately, this form of adaptation not only fails to solve the problem, but exacerbates it, creating a dependence on both the substance and the social environment that normalizes this way of life [12].

DIRECTIONS OF CAUSALITY – WHICH CAME FIRST: ADDICTION OR HOMELESSNESS?

The analysis of the relationship between homelessness and addiction cannot be limited to indicating a cause-and-effect relationship. The work of Katarzyna Chotowska [13] discusses the causes of homelessness among men with higher education. Three out of five respondents indicated alcohol consumption as the direct cause of their homelessness. The other two became involved in alcohol problems only after they became homeless [13].

On the one hand, addiction often leads to the breakdown of family ties, job loss, and eviction, which can result in homelessness. On the other hand, life on the streets is associated with intense stress, uncertainty and trauma. In such situations, psychoactive substances are often the only tool for "emotional regulation".

WOMEN EXPERIENCING HOMELESSNESS AND ADDICTION

The situation of women struggling with homelessness and addiction to psychoactive substances differs significantly from that of men, both in terms of the causes of the crisis and the possibility of overcoming it. Domestic violence, dependence on a partner, family instability and traumatic experiences are the most

Table 1. Psychoactive substance use by men, broken down by age group, type of substance used and sources of funding

Sex	Age	Psychoactive substances used	Procentage of the group [%]	Source of financing	Procentage of the group [%]
Men (46 respondents, 92%)	18-28 years old (1 person)	Cigarettes	100%	Unregistered work	100%
		Cocaine	100%		
	29-38 years old (2 people)	Cigarettes	100%	Informal collection or recyclables	100%
		Alcohol	100%		
		Marijuana	100%		
		Cocaine	50%	theft	50%
		Heroin	50%		
	39-48 years old (9 people)	Cigarettes	100%	Informal collection or recyclables	37.5%
				Benefits	25.0%
		Alcohol	50%	Undeclared/casual work	25.0%
		Marijuana	22.2%	Retirement benefits	12.5%
	49-58 years old (16 people)	Cigarettes	100%	Benefits	41.7%
				Informal collection or recyclables	41.7%
		Alcohol	66.7%	Other Help/Donations/Family	25.0%
		Marijuana	5.9%	Undeclared/casual work	16.7%
		Methadone	8.3%	Social Welfare/Social Insurance (OPS/ZUS)	8.3%
	59-68 years old (15 people)	Cigarettes	91.7%	Benefits	50.0%
				Retirement benefits	41.7%
		alcohol	33.3%	Informal collection or recyclables	16.7%
				Support for the family	8.3%
				No income	8.3%
	68+ years old (3 people)	Cigarettes	100.0%	Retirement benefits	66.7%
		Alcohol	66.7%	Benefits	33.3%
				Retirement benefits	41.7%
		Alcohol	33.3%	Informal collection or recyclables	16.7%
				Support for the family	8.3%
				No income	8.3%
	68+ years old (3 people)	Cigarettes	100.0%	Retirement benefits	66.7%
		Alcohol	66.7%	Benefits	33.3%

Source: Own materials

Table 2. Women's use of psychoactive substances, broken down by age group, type of substance used, and sources of funding

Sex	Age	Psychoactive substances used	Procentage of the group [%]	Source of financing	Procentage of the group [%]
Woman (4 respondents, 8%)	49-58 years old (1 person)	Cigarettes	100%	Informal collection or recyclables	100%
	59-68 years old (3 people)	Cigarettes	100%	Informal collection or recyclables	100%
		Alcohol	100%		

Source: Own materials

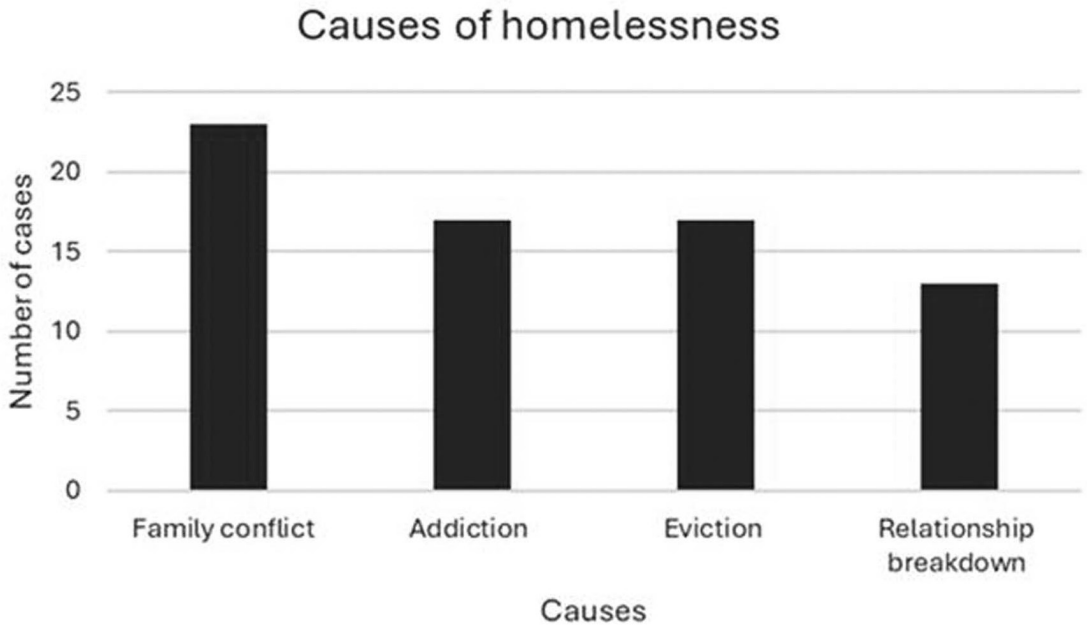

Fig. 1. Causes of homelessness

Source: Own materials

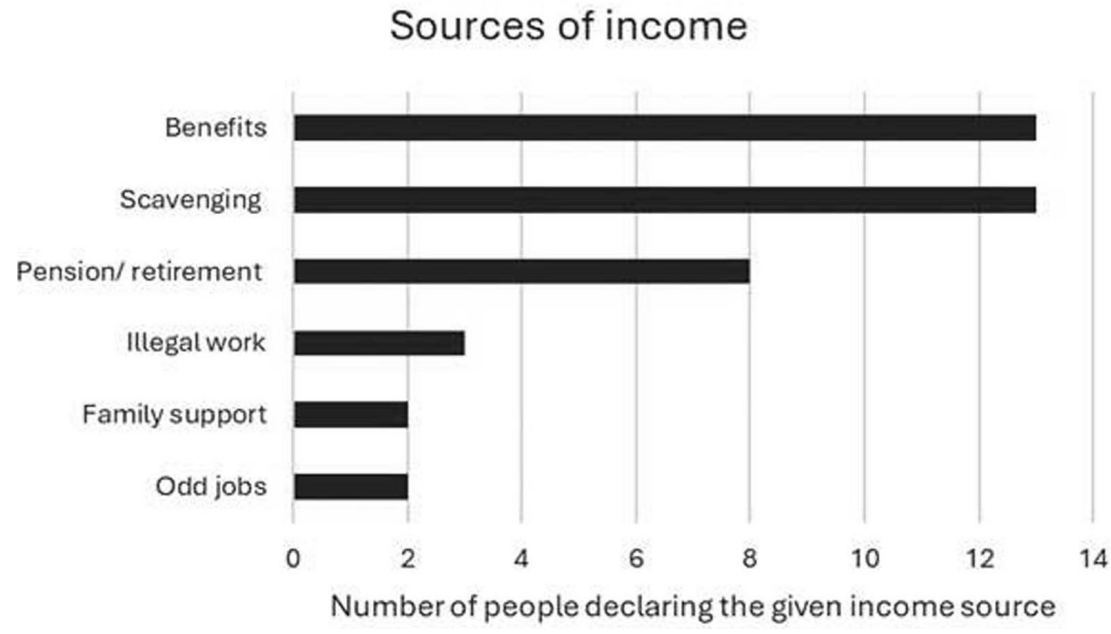

Fig. 2. Sources of income

Source: Own materials

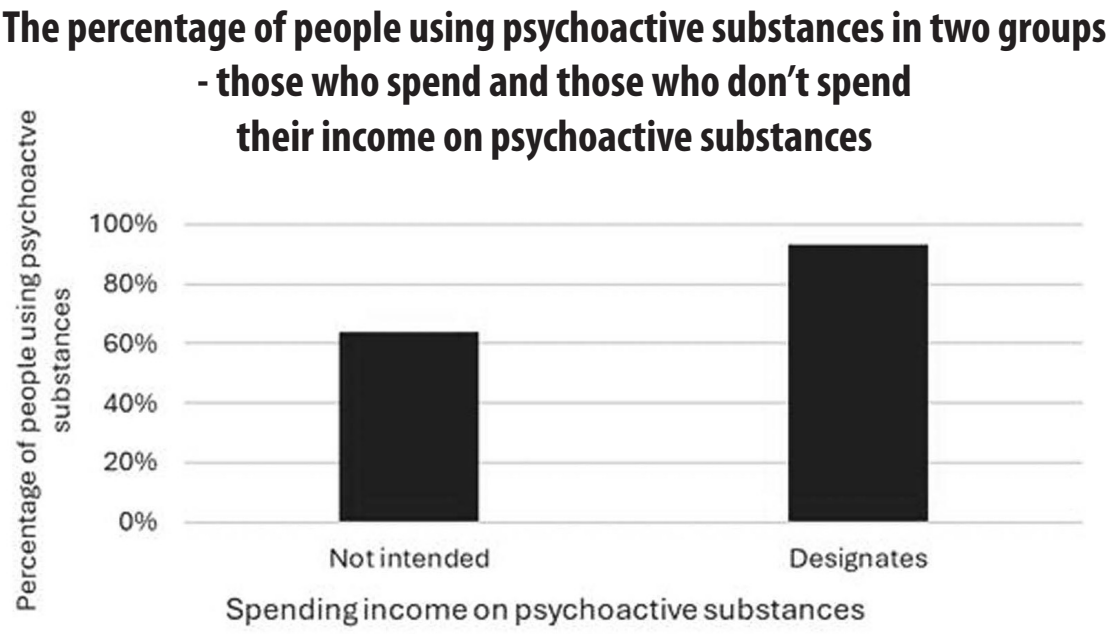

Fig. 3. Percentage of people using psychoactive substances broken down into groups allocating and not allocating income to stimulants

Source: Own materials

frequently mentioned factors leading to the loss of housing. Studies conducted among homeless women show that alcohol and various forms of violence, psychological, physical and economic, are the main causes of homelessness [14]. In many cases, homelessness occurs directly as a result of escalating violence from a partner or family members. Alcohol consumption then becomes a form of escape, and the aggression that occurs after alcohol consumption becomes a form of self-defense [15].

For many homeless women, alcohol addiction often has an adaptive function. Alcohol acts as a means of relieving emotional pain, reducing feelings of loneliness, and providing a temporary escape from harsh reality. Substance addiction often appears to be the only available way to cope with psychological and social difficulties [16].

Another unresolved problem is limited access to support services tailored to women's specific needs. Traditional support systems are most often designed with men in mind, which means that facilities are not adequately equipped in terms of safety, the ability to be with children, or to address the role of violence in the treatment process [17].

TYPES OF SUBSTANCES USED BY RESPONDENTS.

Respondents indicated the use of several types of substances, m.in. cigarettes and alcohol. From a public health perspective, even "soft" substances such as tobacco have serious health consequences. The use of any psychoactive substance is associated with health risks. Every extra cigarette smoked and every extra glass of alcohol we drink brings us closer to potential addiction. Not every substance will immediately cause addiction, but each will have a negative effect on the body in some way. Psychoactive substances affect the brain, altering thought processes, perception of reality, emotions and mood [18].

The use of psychoactive substances, both legal (e.g. alcohol, nicotine) and illicit (e.g. cocaine, opioids), poses a significant challenge to public health and social policy globally. According to data published by the United Nations Office on Drugs and Crime, in 2021, about 296 million people worldwide used drugs, an increase of 23% compared to 2011 [19].

In European countries, according to the European Monitoring Centre for Drugs and Drug Addiction, cannabis also remains the most widely used illicit substance, with 22.6 million Europeans aged 15 to 64 reporting its use in the past year. The report also highlights the growing popularity of cocaine and ecstasy, especially among adolescents and young adults, as well as the increased availability of synthetic opioids and so-called new psychoactive substances, which often circumvent legislation and are difficult to detect in laboratory tests. [10].

The problem of psychoactive substance use also affects Poland, although the overall level of psychoactive substance use is relatively lower than the European average. According to the EMCDDA report, there is a growing interest in cannabis among younger age groups in Poland, with the biggest risk being the low level of user awareness and the unpredictable chemical composition of these substances [10].

SOURCES OF FINANCING FOR THE PURCHASE OF PSYCHOACTIVE SUBSTANCES

According to the declarations of the respondents, the funds for the purchase of psychoactive substances most often come from: garbage collection, pension or disability benefits, work "under the table"

The above-mentioned sources of income indicate a high level of economic marginalization and functioning outside the official employment system. These phenomena are referred to in the literature as "informal survival economics" [20]. The study found that such interventions are characteristic of homeless people, who generally do not have access to benefits or formal employment and yet struggle to meet their needs. Getting money for drugs at the expense of food or clothes proves the psychological dominance of the addiction, substances become the overriding goal of action. This is consistent with the "compulsion model" described in the literature, according to which an addicted person is not guided by a rational assessment of the situation, but by the need to satisfy a substance craving [17].

LIMITATIONS OF THE STUDY

This study has a number of limitations that should be taken into account when interpreting the results. The relatively small size of the sample (N = 50) may limit the possibility of generalizing the results to a wider population of people experiencing homelessness in Poland. Reaching this population and obtaining informed consent has been a challenge, and despite efforts to include a representative sample, the size remains relatively small. In addition, there was a gender imbalance in the study group, with only 8% of participants identifying as female (n = 4). Although the gender distribution in our sample differs slightly from about 16-20% found in national studies [9], this imbalance is due to the difficulty in reaching women in this population. It is worth noting that nearly 200 people experiencing homelessness were contacted during the recruitment process. However, due to a lack of willingness to talk or visible substance intoxication, it was not possible to conduct interviews with all of them. As a result, the estimated response rate was around 25 percent. In addition, the ability to reach a representative group of women was limited due to their lower availability in the general population of people experiencing homelessness. Still, we believe the study continues to provide valuable information on the wider problem of homelessness.

Another factor to consider is the geographic scope of the study. The study was conducted exclusively in Warsaw, which means that the results may have been influenced by local factors such as the availability of support services, urban characteristics and social policies. As a result, the results may not reflect the situation in other cities or rural areas, where the context can vary significantly. However, this study may reflect the urban example of the city, which may also be representative of the situation in other cities in Poland.

The CAPI research method used was chosen because of its effectiveness in collecting data in the respondents' natural environment. However, this method can be prone to a social approval effect, which may result in respondents changing their responses to accommodate societal expectations, especially for sensitive topics such as substance use. We are aware of this potential limitation, but we have made efforts to minimize it through careful training of interviewers and a non-judgmental approach to sensitive questions.

Finally, the study used a questionnaire developed by the author, which was not formally validated or tested for reliability. However, the tool was based on the results of a nationwide survey on homelessness in Poland [9], which provided valuable information on the characteristics and challenges faced by this population. Although no formal validation of the questionnaire has been carried out, we believe that the tool is relevant for the purposes of the study and provides important information about the experiences of homeless people in Poland.

CONCLUSIONS

The results of this study support the hypothesis of a two-way relationship between addiction and homelessness, substance use may act as both a risk factor for homelessness and a coping mechanism for homelessness. The results point to the need for further in-depth research and the development of integrated interdisciplinary strategies to support people experiencing homelessness. Such strategies should include addiction treatment, social intervention and reintegration programmes.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest.

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ORIGINAL ARTICLE

Emergency medical response systems in the European Union: A qualitative comparative study with practical recommendations for civil protection reform in Poland

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ABSTRACT

Aim: To analyse the functioning of emergency medical systems in selected European Union (EU) countries based on an original survey, with emphasis on the role, capabilities, and cooperation models of fire services in pre-hospital emergency care.

Materials and methods: A questionnaire was distributed to 26 EU countries between July and August 2022. Responses were obtained from Belgium, Latvia, Italy, Czech Republic, Malta, Slovenia, Austria, and Denmark. A study visit to Romania provided additional insights. Due to incomplete and inconsistent responses, the findings were analysed qualitatively.

Results: Belgium is the only responding country where ambulances operate within the fire service structure. Other countries maintain separate EMS systems but cooperate operationally with fire services. While equipment standards are nationally unified in most systems, training, competencies, and deployment policies differ.

Conclusions: Belgium's integrated fire-medical model shows that with central coordination, clear division of responsibilities, and joint training, overall system efficiency and resilience can be improved. Such measures could enhance response times, optimise resource use, and strengthen preparedness for mass-casualty incidents or national emergencies.

KEY WORDS

fire service, civil protection, emergency medical service, civil defence, pre-hospital care, inter-service cooperation

INTRODUCTION

In December 2024, the Parliament of the Republic of Poland adopted the Civil Defence and Civil Protection Act, which came into force on 1 January 2025. The Ministry of Interior and Administration had been working on the Act's revision for several years. The legislation addresses multiple areas of public safety, one of which concerns the functioning of the National Firefighting and Rescue System (NFRS), built around the State Fire Service (SFS) and Volunteer Fire Brigades (VFB). Public consultations and expert teams had been engaged since 2022 to ensure that the scope and provisions of the new Act would align with contemporary threats and the operational capacity of services. Experts from uniformed services were also involved in drafting the provisions [1].

The solutions introduced in the Act address the entire cycle of crisis management, secure investment in infrastructure and personnel, and update the tasks of rescue services and public administration both in peacetime and during wartime. A major goal is to enhance pre-hospital medical capabilities, a need underscored by experiences during the COVID-19 pandemic, when shortages in Emergency Medical Service (EMS) teams led to isolated medical rescue interventions being carried out by firefighters on a large scale nationwide. The Act also draws on lessons learned from the mass influx of refugees from Ukraine during the first year of the armed conflict with Russia [2-4].

The State Fire Service contributed to the preparation of implementing regulations for the development of medical rescue within the service. One of the preparatory measures was the organisation of an international consultation in the form of a questionnaire survey [5,6].

The tasks assigned to governmental entities under the Act are broad, including:

- Coordination of civil protection and civil defence activities by relevant entities.
- Analysis of potential hazards and risk assessment.
- Organisation and provision of humanitarian aid within the country, creation and maintenance of civil protection resources for immediate domestic deployment.

- Establishment of alert, warning, and alarm systems for hazards.
- Maintenance of a central civil protection resource database, public awareness and education campaigns on hazards.
- Organisation of international cooperation, needs planning in line with available financial resources.
- Coordination of emergency aid delivery, and research activities in the field of civil protection and civil defence [7-10].

AIM

This study aimed to analyse the functioning of rescue systems in European Union (EU) countries through a custom-designed questionnaire. The objective was to identify experiences and best practices in the organisation of pre-hospital emergency care, with particular attention to the role, operational capabilities, and competencies of fire services within national emergency medical systems.

MATERIALS AND METHODS

STUDY DESIGN

This study employed a qualitative descriptive design using an original, structured questionnaire developed by the authors. The tool contained both closed and open-ended questions, with the latter allowing respondents to provide narrative descriptions of their national rescue systems. The questionnaire was sent to 26 EU member states between 1 July and 15 August 2022. The purpose was to gather comparable qualitative information on the organisation of emergency medical systems, particularly the role of fire services in pre-hospital care, to inform legislative work on the Civil Defence and Civil Protection Act in Poland.

A complementary component of the study was a field visit to Romania on 10-12 October 2022 by a delegation of Polish SFS representatives. Romania was therefore excluded from the questionnaire distribution list.

STUDY PROCEDURE

Participation in the survey was voluntary, and each country had full discretion in how to respond. The questionnaire was sent in English to the department or office responsible for coordinating rescue services in each country. Once distributed, the SFS Headquarters had no influence over the number, scope, or quality of responses. Several limitations were noted:

- selective answers to specific questions,
- omission of certain questions,
- "Yes" or "No" answers where justification or descriptive input was requested,
- lack of any response in some cases.

QUESTIONNAIRE STRUCTURE

The questionnaire consisted of an introductory letter explaining the purpose of the request, followed by 20 research questions grouped into thematic areas:

- medical rescue capacity within the fire service,
- cooperation between fire services and the emergency medical system,
- personnel (crew size, qualifications, qualification process),
- equipment (ambulances, rescue vehicles, medical equipment),
- training cycles for personnel,
- resource allocation during crises or wartime,
- opinions on current and future system capacity.

STUDY POPULATION

The questionnaire was sent to 26 EU member states. Responses were received from Belgium, Latvia, Italy, the Czech Republic, Malta, Slovenia, Austria, and Denmark. In total, 8 out of 26 countries completed the survey, representing approximately 31% of those invited. The analysis is descriptive in nature, without the possibility of statistical comparisons.

DATA ANALYSIS

Responses were analysed using thematic content analysis, grouping information into categories corresponding to the questionnaire's thematic sections. Given the variability and incompleteness of responses, no statistical comparisons were possible, and findings are presented as a qualitative synthesis.

ETHICAL CONSIDERATIONS

All responses were fully anonymised. The study adhered to the principles of the Declaration of Helsinki and did not require bioethics committee approval. Consent to access the survey results and use them for scientific purposes was obtained in January 2025.

RESULTS

The following section presents the organization, management, and operational aspects of EMS in the countries that responded to the survey. For clarity, results are summarized narratively for each country, preserving original details while improving coherence.

BELGIUM

Belgium operates a two-tier EMS system consisting of standard ambulances and Medical Urgency Group (MUG) units. Ambulances, equipped with standard medical supplies, are staffed by two paramedics who provide first aid on-site and transport patients to accredited emergency departments selected by EMS dispatchers based on the shortest travel time.

MUG units are vehicles equipped for advanced pre-hospital care and staffed by a physician and an emergency nurse. They provide on-scene treatment and may accompany patients in ambulances but lack independent transport capability. In 2007, a Paramedical Intervention Team (PIT) concept was introduced, replacing one paramedic with an emergency nurse trained to handle more serious cases. Although full implementation was limited by budgetary constraints, cooperation agreements be-

tween EMS and hospitals have progressively expanded the PIT system.

Approximately 60% of ambulances are operated by the fire service, with the remainder run by hospitals or private organizations such as the Red Cross. The fire service manages around 250 ambulances nationwide, with vehicle allocation varying by station. All ambulances, regardless of operator, are subject to the same federal equipment and staffing regulations.

Responsibility for the EMS system rests with the Federal Public Service for Public Health, Food Chain Safety, and Environment, which oversees contracts with providers, ambulance inspections, and dispatcher training. Dispatch infrastructure and personnel are managed by the Federal Public Service – Home Affairs, operating ten dispatch centres nationwide.

Belgian regulations require MUG units to be located to reach most of the population within 10 minutes, with minimal areas exceeding 15 minutes. Firefighters assigned to ambulances must complete a resuscitation training course, while operational firefighters responding to accidents receive basic life support (BLS) training provided by the Red Cross. During large-scale emergencies, fire service ambulances are supplemented by Red Cross vehicles.

Belgium emphasizes central coordination, standardized training, and clear inter-agency agreements as key factors ensuring system efficiency and resilience.

CZECH REPUBLIC

EMS in the Czech Republic is provided by 14 regional organizations authorized under the Health Services Act No. 374/2011 Coll. on Emergency Medical Services. The Ministry of Health manages EMS providers as part of the Integrated Rescue System, while operational dispatch centres operate continuously at the regional level.

Response coverage plans require EMS to reach any municipality within 20 minutes of dispatch. Although fire services do not operate ambulances, they support EMS through specialized roles. Notably, the "firefighter–paramedic" concept trains firefighters for medical support in complex rescue environments, including building collapses and hazardous materials incidents. During the COVID-19 pandemic, firefighters with medical qualifications also performed testing duties.

Table 1. Comparative summary of EMS systems in responding countries

Country	EMS System Structure	Ambulance Operators	Fire Service Ambulances	Dispatch System	Max. Response Time	Notable Features / Cooperation Models
Belgium	Two-tier (Ambulance + MUG/PIT)	Fire service, hospitals, private	Yes (~60%)	Centralized, national	MUG: 10–15 min	Equal treatment of all ambulances; joint training
Czech Republic	Regional EMS organizations	Regional EMS organizations (contributory)	No	Regional centres	≤20 min (by region)	"Firefighter–paramedic" concept; COVID-19 support
Latvia	National SEMS	SEMS only	No	Centralized, national	12–25 min (urban–rural)	40h first aid training for firefighters
Malta	Ministry of Health	Public	No	Centralized, hospital	<15 min (island-wide)	Full resource pooling during crises
Slovenia	Health centres + hospitals	Public	No	Medical Dispatch Centre(s) (level not specified)	≤15 min; 1 min departure	Firefighters trained in BLS, trauma care
Italy	Regional EMS + volunteers	Public + volunteer associations	No	Regional operational	Not standardized nationally	CBRN cooperation fire service–EMS
Austria	Federal states (9 regions)	Red Cross, rescue organizations	No	Mixed (regional/local)	Defined by federal states	Specialized mountain/ cave rescue units
Denmark	5 regional EMS systems	Public + private contracts	No	Regional centres	Regional regulations	Regional autonomy in EMS provision
Romania	National EMS + fire service	Public (Department for Emergency Situations)	Yes	Centralized, national	Not specified	Integrated 112 dispatch, career + volunteer units
Poland*	NEMS + NFRS	Public	Yes (support role)	Regional + joint ops	Not standardized nationally	31,500 career + 400,000 volunteers; HEMS support

*Poland presented for comparative purposes only

Source: Own materials

Fig. 1. Ground rescue resources in the emergency medical system

Source: Authors' archive

LATVIA

Latvia's EMS is centralized under the State Emergency Medical Service (SEMS), responsible for nationwide emergency call reception, ambulance team coordination, and hospital transfers. SEMS also oversees ground and air medical evacuation, with inter-agency agreements enabling collaboration with the National Armed Forces and the State Border Guard.

Regulations define ambulance response times as 12 minutes in national cities, 15 minutes in regional cities, and 25 minutes in rural areas. SEMS and the State Fire and Rescue Service (SFRS) operate as separate but complementary entities, with specially trained firefighters authorized to administer certain medical interventions under physician supervision during prolonged rescues. Firefighter training includes a 40-hour first aid curriculum covering trauma, chemical injuries, mass-casualty incidents, and acute medical conditions.

MALTA

In Malta, EMS is managed by the Ministry of Health, operating continuously and linked directly to emergency services at Mater Dei Hospital. While there are no legally defined response times, the island's size ensures responses typically within 15 minutes.

During national crises, all agencies- including Civil Protection, Armed Forces, and Health Services- pool resources under central health management. Public perception of EMS is highly positive, with services valued for dedication and efficiency.

SLOVENIA

Slovenia's EMS includes health centres, hospitals, medical dispatch centres, and helicopter units. Services cover urgent interventions and patient transport, delivered by mobile units staffed by paramedics, medical graduates, and in some cases, physicians.

The Ministry of Health coordinates EMS organization and oversight, with dispatch centres responsible for call reception and resource deployment. Regulations require average response times not exceeding 15 minutes, with units departing within one minute of call receipt.

Firefighters, though not providing EMS directly, receive basic life support training from the Slovenian Red Cross, particularly for road accidents. Training includes resuscitation, trauma care, and emergency procedures for burns, hypothermia, drowning, and other life-threatening conditions.

ITALY

Italy's EMS is a public service integrated with regional health systems. The emergency number 118, linked to 112 under EU regulations, operates 24/7 with physicians and nurses coordinating ambulances, physician-staffed vehicles, and Helicopter Emergency Medical Service (HEMS) units.

Volunteer associations, including the Italian Red Cross, provide significant support in staffing and logistics. Italy is also expanding cooperation between fire services and regional EMS, particularly in managing chemical, biological, radiological, and nuclear (CBRN) incidents.

AUSTRIA

EMS responsibility in Austria lies with the nine federal states, each defining its own quality and coverage requirements. Municipalities contract recognized rescue organizations, such as the Red Cross, to ensure access.

While special units (e.g., mountain or cave rescue) exist, fire services do not operate ambulances, and EMS dispatch systems vary between federal and regional levels.

DENMARK

Denmark's EMS is organized across five regions, each with its own dispatch centre. Services are provided di-

rectly by regional authorities or through contracts with private operators. Fire services do not operate ambulances, and response time standards are set regionally rather than nationally.

ROMANIA

Information on Romania's EMS derives from a study visit by Polish firefighters. The system is coordinated centrally through the Department for Emergency Situations, with integrated 112 dispatch centres staffed by doctors, paramedics, firefighters, and police officers.

Fire services in Romania maintain ambulances, medical kits on fire engines, and HEMS units, operated by both career and volunteer personnel. Centralized coordination ensures efficient multi-agency responses during complex emergencies.

Ground and air rescue resources are presented in Figures 1–2.

POLAND

Given incomplete responses from other countries, Polish EMS operations are presented for comparison. The SFS employs approximately 31,500 career firefighters and over 400,000 trained volunteers, operating from 504 rescue–firefighting units. An important component of fire and local hazard response is the provision of qualified first aid: every firefighter completes a certified 66-hour BLS course covering both trauma and non-trauma mechanisms. Approximately 2,500 career firefighters hold formal medical qualifications (physician, paramedic, or nurse). The National Fire Service Academy (the country's only fire officer school) offers bachelor's programs in emergency medical rescue, ensuring a steady increase in medically qualified firefighters [1, 11].

Poland's National Emergency Medical System (NEMS) comprises 1,697 ambulances, 234 emergency departments, and 22 HEMS bases [13]. Operational cooperation between NEMS and the NFRS includes joint rescue operations, support for HEMS landings and takeoffs, and specialist joint interventions by SFS teams within restricted hazard zones that are inaccessible to medical services due to personal protective equipment limitations [12–17]. These capacities position Poland to selectively adopt elements of the Belgian approach-notably centralized, shared dispatch, expanded paramedic training pathways for firefighters (including volunteers), and regular joint inter-agency exercises, without full structural integration [1, 3, 14, 17].

For comparative clarity, Table 1 summarizes key organizational characteristics of EMS systems and the involvement of fire services across all responding EU countries.

Fire service involvement in EMS operations and medical training requirements across the responding countries are summarized in Table 2.

DISCUSSION

This qualitative comparative study examined the organisation and operational role of fire services within EMS in selected EU countries. The findings reveal substantial variability in how fire services are integrated, or remain separate, from national EMS structures. Belgium was the only country among respondents where

Table 2. Fire Service Involvement and Medical Training in EMS Systems

Country	Fire Service Ambulances	Firefighter Medical Training Requirements	Role of Fire Service in EMS
Belgium	Yes (~60%)	Resuscitation course + BLS training	Full EMS integration, ambulance operations
Czech Republic	No	Firefighter–paramedic concept (specialized)	Support in disasters, hazardous environments
Latvia	No	40h first aid, pain relief under physician	Complementary role in prolonged rescues
Malta	No	Not specified	Crisis resource pooling only
Slovenia	No	BLS, trauma care by Slovenian Red Cross	First responders before EMS arrives
Italy	No	Volunteer-based training for EMS support	CBRN cooperation with regional EMS
Austria	No	Not specified	Specialized rescue (mountain/cave) only
Denmark	No	Not specified	Minimal EMS involvement
Romania	Yes	EMS-capable fire crews (training specifics not detailed)	Integrated EMS–fire service model
Poland*	Yes (support role)	66h BLS + certified medical rescuers	Joint ops, HEMS support, hazardous zones

*Poland presented for comparative purposes only

Source: Own materials

ambulances operate within the fire service framework, while in all other countries, fire services provide supportive, rather than primary, pre-hospital medical functions. Similar conclusions regarding the diversity of EMS – fire service cooperation models have been reported in prior analyses of the National Firefighting and Rescue System in Poland, particularly in rural contexts, where cooperation with EMS is often based on specific operational agreements rather than structural integration [14,17].

The Belgian model demonstrates the potential benefits of full integration between fire and medical services under a centrally coordinated system. Equal treatment of ambulances, regardless of whether they are operated by hospitals, private providers, or fire services, fosters flexibility in resource allocation and ensures consistent equipment and training standards. Such integration could be a valuable reference for countries considering reforms aimed at optimising EMS response times, resource distribution, and readiness for large-scale emergencies. Previous research indicates that strong inter-agency coordination, supported by centralised command structures, is a key factor in improving emergency preparedness and operational efficiency [8, 14, 16].

In contrast, systems in other responding countries maintain a clearer separation between firefighting and medical rescue operations. Cooperation is typically achieved through formal agreements, joint training, and coordinated dispatch protocols. While this approach allows each service to retain specialised competencies, it may limit opportunities for resource sharing in times of peak demand or mass-casualty incidents. This finding aligns with observations from studies of Poland's National Emergency Medical System during the COVID-19 pandemic, which emphasised the importance of flexible task allocation and inter-service support in situations of workforce shortages [2,16].

From a policy perspective, the results suggest that both integrated and cooperative models can function effectively if they are supported by clear legal frameworks, standardised training requirements, and robust inter-agency communication. For Poland, where the State Fire Service already possesses significant personnel and equipment resources, selectively adapting elements from the Belgian model – such as shared dispatch systems or expanded paramedic training for firefighters – could enhance operational flexibility without fully merging organisational structures. These proposals are consistent with the objectives of the Civil Defence and Civil Protection Act, which aims to strengthen pre-hospital capabilities and optimise the use of existing emergency service resources [1,3].

The qualitative nature of this study allowed for the exploration of diverse organisational and operational approaches, but also introduced certain limitations. The analysis was based on voluntary and incomplete responses, meaning that not all perspectives within each country were captured. Furthermore, the absence of detailed operational data from some states limited the ability to assess the direct impact of organisational structures on performance outcomes. Similar methodological constraints have been noted in other comparative analyses of international rescue systems, where data collection depends heavily on the willingness and capacity of agencies to share internal information [8, 15]. Future studies could address these gaps by conducting structured interviews with key stakeholders, analysing incident response records, and expanding the scope to include non-EU countries with comparable demographic and geographic conditions.

Ultimately, the findings contribute to the growing body of knowledge on cross-sector cooperation in emergency response. They underline the importance of flexibility, interoperability, and context-specific solutions when designing or reforming national civil protection and rescue systems. As noted by Gałązkowski et al. [14], the integration of resources and procedures between fire services and EMS, whether partial or full, can significantly improve response capacity in both everyday operations and during extraordinary events.

LIMITATIONS

This analysis is descriptive in nature due to incomplete and inconsistent data. Not all questions received responses, and not all countries replied to the survey. The authors had no influence over the type, scope, or quality of the answers provided. Participation was voluntary and in the form of information sharing. Language barriers in some countries may have affected both the number and quality of responses, despite the questionnaire being distributed in English.

CONCLUSIONS

Among responding countries, only Belgium has ambulances within the fire service structure. In other countries, fire services do not provide EMS but cooperate with EMS personnel. Fire service ambulances are treated equally to those from hospitals or private organisations and are dispatched mainly to urgent incidents. Firefighters assigned to ambulances must complete specialised medical training. All ambulances carry identical equipment according to national regulations. The number of ambulances per fire station is not fixed.

Belgium's model shows that with central coordination, clear division of responsibilities, and joint training, integration of fire and medical services can improve system efficiency and resilience. Such measures could enhance response times, optimise resource use, and improve preparedness for mass-casualty incidents or national emergencies. For Poland, adopting selected elements of this approach, without fully merging organisational structures, could strengthen operational capacity and flexibility in emergency medical response.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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Difficult intubation in pediatric patients

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ABSTRACT

Aim: To assess the course of endotracheal intubation in pediatric patients treated at the Institute of Mother and Child in Warsaw and estimate the difficulties.
Material and methods: The methodology of the study was based on a retrospective analysis of medical data using the records on endotracheal intubations performed in pediatric patients at the Institute of Mother and Child in Warsaw.
Results: The study group consisted of 117 patients who came from different departments: the Department of General Surgery, the Department of Cleft Surgery, the Department of Endoscopy, the Department of Oncology, the Department of Intensive Care and the Department of Orthopaedics. The largest group consisted of general surgery patients, i.e. 49 patients. The second largest group was the cleft surgery ward, where 32 patients were examined.
Conclusions: The study on paediatric endotracheal intubation at the Institute of Mother and Child in Warsaw highlights the importance of improving patient safety and treatment outcomes. It recommends standardizing airway management procedures and developing a protocol for difficult intubations, tailored to each patient's age, condition, and anatomy. Regular evaluation and updates of these protocols are advised, along with ensuring proper environmental and infrastructural conditions for intubation. Additionally, continuous education and hands-on training for medical staff are emphasized, as their competence directly affects the safety and success of paediatric intubations.

KEY WORDS

intubation, difficult airway, intubation in children

INTRODUCTION

Endotracheal intubation is a key medical procedure. It ensures airway patency by means of inserting an endotracheal tube and is used in various clinical situations, such as administering mechanical ventilation or general anesthesia. The effectiveness of intubation depends on the patient's anatomy, the choice of equipment and the techniques used during the procedure [1]. Endotracheal intubation in pediatric patients can be more complicated than in adults, due to the specific anatomical and physiological characteristics of this age group. Children have a larger head in relation to the rest of the body, therefore their pharynx and larynx are higher and more anteriorly displaced. The larynx of children is smaller and conical, and its structures more delicate. It is located higher than in adults, so special care must be taken during intubation. The trachea of children is narrower and shorter than in adults, which requires precise selection of the endotracheal tube. The bronchi are less developed and more sensitive when compressed. As a result, ventilation is affected, therefore adjustment of ventilation parameters is necessary. Due to the lower body weight of children, it is necessary to adapt the tidal volume and respiratory rate to their age. Children have a higher respiratory rate and are more prone to hypoxia than adults, so ventilation parameters should be adjusted accordingly. Their smaller airway diameter increases resistance to airflow, therefore proper selection of the endotracheal tube is important. Children's respiratory control system is at a developmental stage, which can affect their response to the stress of intubation. Knowledge of these differences is vital in order to ensure safe and effective intubation in children [2-10]. Moreover, traditional methods of assessing the difficulty of intubation, such as the Mallampati scale or the Wilson scale, can be less useful in pediatric patients [10, 11]. Medical personnel should be well informed and trained concerning the above aspects to minimize the risk of complications. Intubation should be performed by anesthetists, critical care doctors or emergency physicians with appropriate qualifications and experience. Knowledge and skill in intubation are crucial to the effectiveness and safety of the procedure. Risks, such as intubation difficulties, risk of bleeding or damage to anatomical structures, should be assessed before intubation. It is important to check the availability and fit of intubation equipment, including different sizes of endotracheal tubes, laryngoscope, ventilation sets and parameter monitors [11]. During intubation, haemodynamic parameters, such as blood pressure, heart rate and oxygen levels (SpO_2) should be monitored in order to assess the patient's stability and detect possible complications related to the procedure in the shortest possible period. As soon as the endotracheal tube is inserted into the trachea, it is important to confirm its cor-

rect position. This can be done by checking the visibility of the endotracheal tube on laryngoscopy, observing chest movements during ventilation, auscultating the lungs and observing end-expiratory CO_2 concentration on capnography [12-14].

Following the above guidelines ensures safe and effective intubation, minimizing the risk of complications. It is vital to always consult with your medical team and follow established protocols and guidelines. Endotracheal intubation is a key procedure in the care of pediatric patients, used for severe respiratory infections, acute respiratory failure, cardiac arrest, trauma or during medical procedures. It makes it possible to control breathing, oxygen delivery, carbon dioxide removal and prevents aspiration of gastric contents [15, 16]. In severe respiratory infections, such as pneumonia or sepsis, intubation provides ventilation and airway protection [17, 18]. During sudden cardiac arrest, it enables effective ventilation and drug administration [15, 19]. Severe injuries, including traumatic brain and chest ones, require intubation to maintain airway patency and effective ventilation [15, 20-22]. In the course of general anesthesia, intubation provides respiratory control during the procedure. Intubation also protects against aspiration of gastric contents, which is important in children undergoing medical procedures [23]. An endotracheal tube with a sealing cuff further protects the airway and prevents choking. Performed correctly, intubation can be crucial to a pediatric patient's survival and prognosis in critical situations. Research by Fiadjoe and Nishisaki (2012-2015) identifies several key factors contributing to intubation difficulties in pediatric patients. Significant problems may arise from anatomical differences, such as the small size of anatomical structures in children, narrow airways and greater susceptibility to stenosis. All of these factors make insertion of the endotracheal tube more difficult. In addition, chronic edema, the presence of tumors, inflammatory lesions and foreign bodies in the airway can also pose challenges during the intubation procedure [24]. The experience of medical personnel is another important factor. As Weiss and Engelhardt (2010) underline, intubation skills and the experience of the person performing the procedure are key to conducting effective intubation in pediatric patients [25]. Experience and knowledge of specific techniques can significantly affect success. The availability of appropriate intubation equipment also plays an important role. Vlatten et al. (2011) compared intubation using a video laryngoscope with a traditional laryngoscope, pointing out the importance of the choice of intubation tools, especially in difficult cases, such as in children with impaired mobility in the cervical spine [25].

There are various medical scales for assessing the difficulty of endotracheal intubation to help physicians identify potential difficulties. The Cormack-Lehane scale is commonly used in anesthesiology to assess the visual field during the intubation procedure. It consists of four grades:

1. Grade I: Full view of the glottis.
2. Grade II: The glottis is partially visible, but the front part is obscured by the tongue.
3. Grade III: Only the epiglottis is visible, and the glottis is not visible.
4. Grade IV: The epiglottis is not visible.

The higher the grade on the Cormack-Lehane scale, the more difficult the endotracheal intubation. Higher grades mean poorer visibility of the glottis, which can lead to difficulty or failure in inserting the endotracheal tube into the trachea. The Cormack-Lehane scale classification is an important tool for assessing the difficulty of intubation and helps anesthesiologists to make decisions about intubation strategy and to prepare a contingency plan in case difficulties arise during the procedure [26-28].

AIM

The aim of the study is to assess the course of endotracheal intubation in paediatric patients treated at the Institute of Mother and Child in Warsaw and estimate the difficulties. Its objective is to collect data on intubation procedures, analyze the difficulties and complications encountered, and to identify the factors influencing these difficulties, such as age, airway anatomy, medical conditions and staff experience. The results of the assessment can help improve intubation techniques, protocol development and staff training, which will contribute to increasing safety and improving the quality of care for paediatric patients at the Institute of Mother and Child.

MATERIAL AND METHODS

The methodology of the study was based on a retrospective analysis of medical data using the records on endotracheal intubations performed in paediatric patients at the Institute of Mother and Child in Warsaw between 8 April 2023 and 25 May 2023. The study examined 117 forms from 8 April 2023 to 25 May 2023. The selection of patients for the study was based on specific criteria, such as age (under 18 years and those patients in whom intubation time was measured), intubation procedure and availability of complete data. Various factors included in the endotracheal intubation assessment form were considered during the analysis. The form that was used listed the following questions to be filled in by the anaesthesiologist performing the intubation:

- Number of years the doctor specialized in anaesthesia and work experience.
- Laryngoscope of choice (classic laryngoscope, video laryngoscope).
- Type of endotracheal tube.
- Additional interventions and equipment to assist endotracheal intubation: tracheal shift during intubation, change of laryngoscope blade, rigid guidewire, Magill forceps, Bougie guidewire, additional doctor to assist, additional nurse to assist,
- Change of laryngoscope (to videolaryngoscope, to classic).

- Route of intubation (nasal, oral).
- Patient's body weight.
- Factors affecting the level of intubation difficulty (physiological and pathological features of the paediatric patient): craniofacial malformations, cleft lip, cleft palate, polydactyly, neonate, premature infant, malformation syndrome.
- Airway (difficult airway, difficult mask ventilation, difficult laryngoscopy, inability to intubate).
- Cormack-Lehan score.
- Intubation time.
- Subjective assessment of difficulty

RESULTS

The study group consisted of 117 patients who came from different departments: the Department of General Surgery, the Department of Cleft Surgery, the Department of Endoscopy, the Department of Oncology, the Department of Intensive Care and the Department of Orthopaedics. The largest group consisted of

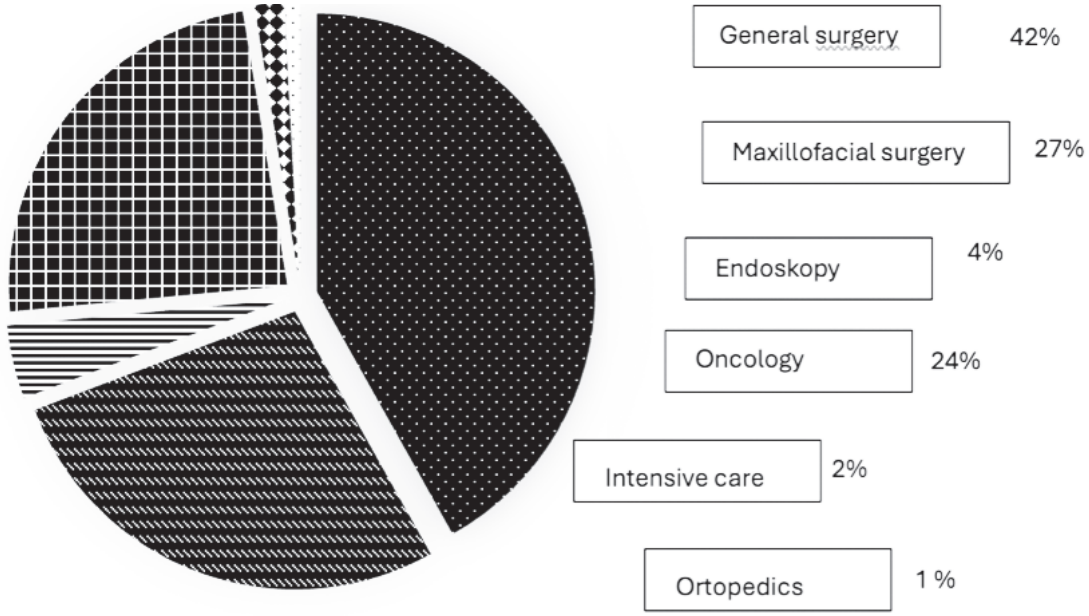

Fig. 1. Percentage distribution of patients by referral unit

Source: Own materials

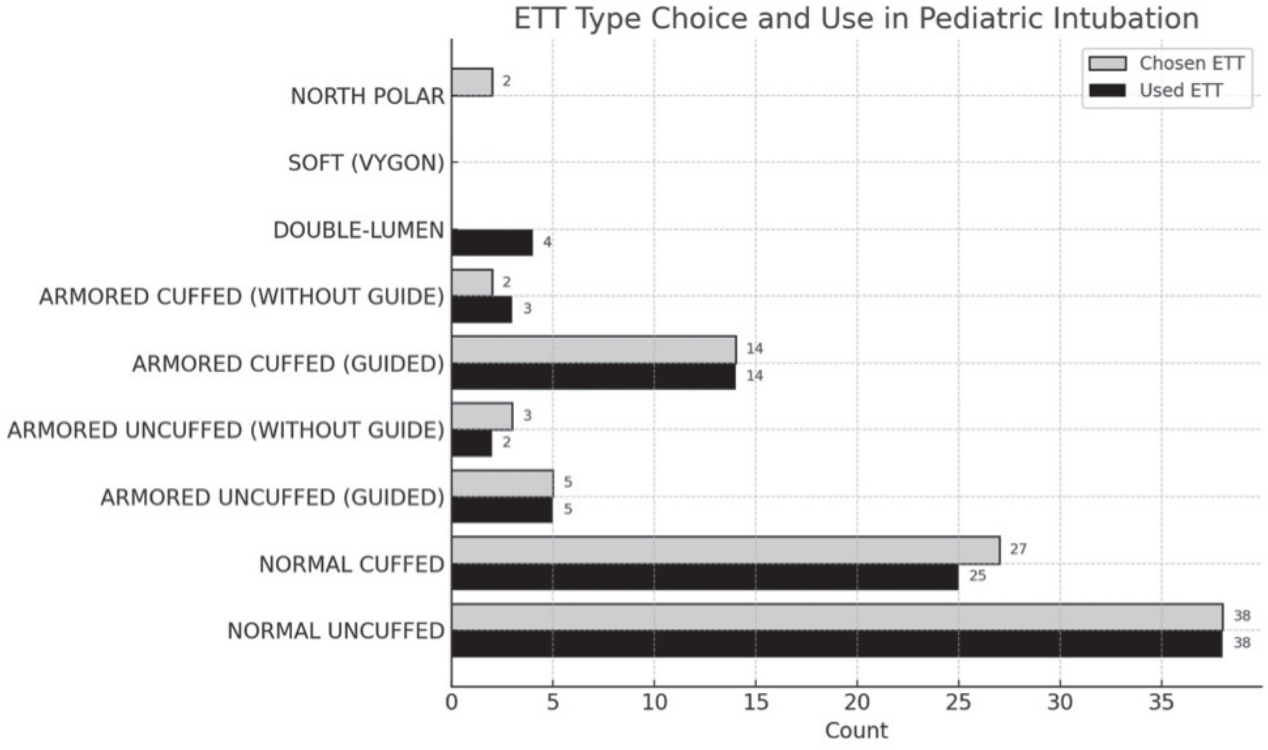

Fig. 2. Intubation tubes used during the study

Source: Own materials

general surgery patients, i.e. 49 patients. The second largest group was the cleft surgery ward, where 32 patients were examined. There were also 28 oncology patients among those examined. The groups with small numbers were: endoscopy (5 patients), the Department of Intensive Care (2 patients) and orthopaedics (1 patient) (Fig. 1).

The number of years of having the specialty in anaesthesia at the Institute of Mother and Child varies from 4 to 30 years. The average is around 20 years of experience, while the average length of work in the field is 14.01 years. A classical laryngoscope was overwhelmingly chosen for intubation. A videolaryngoscope was used in only 0.85% of the cases in the study population. For endotracheal intubation, a plain endotracheal tube without a sealing cuff was most commonly used. Ordinary tubes with a sealing cuff and reinforced tubes without a cuff on a rigid guidewire were used with equal

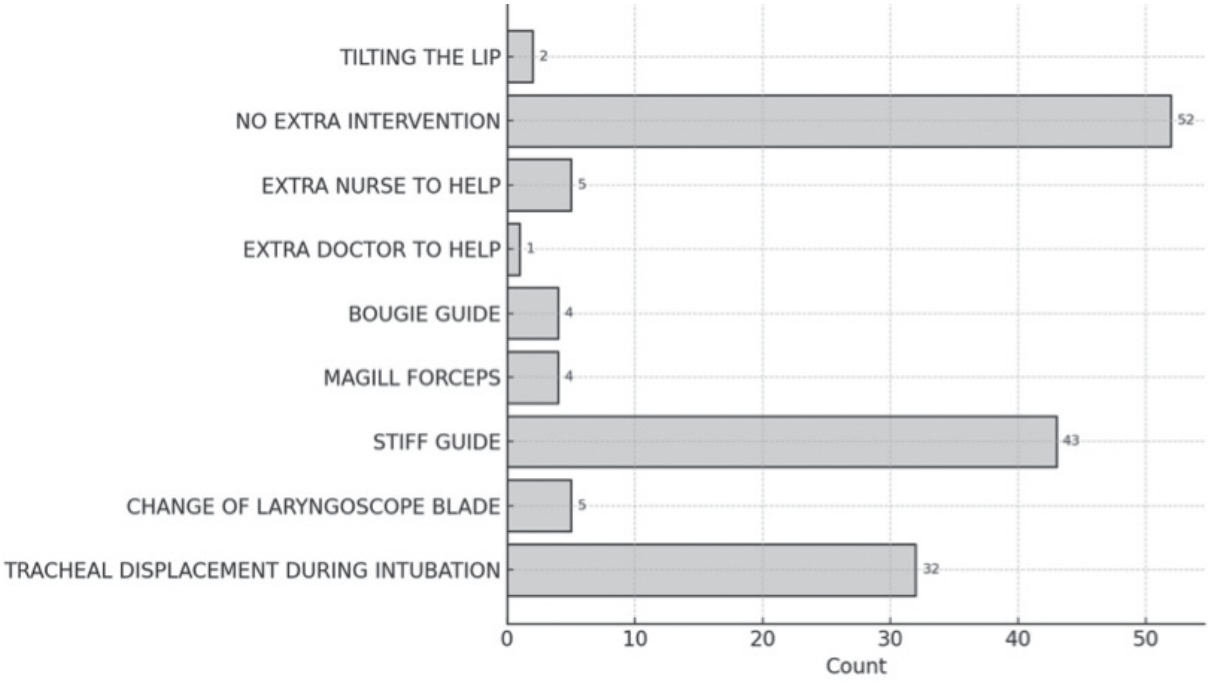

Fig. 3. Additional interventions and equipment to support endotracheal intubation

Source: Own materials

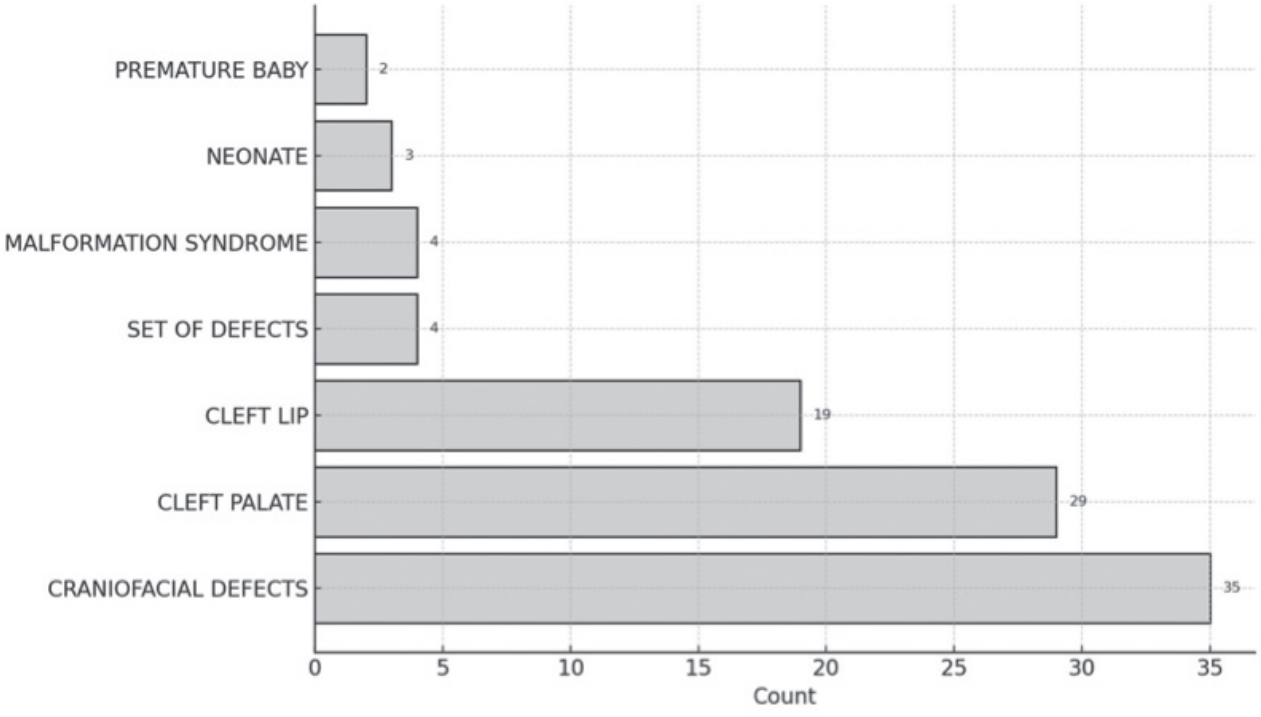

Fig. 4. Factors affecting difficulty of intubation – prevalence

Source: Own materials

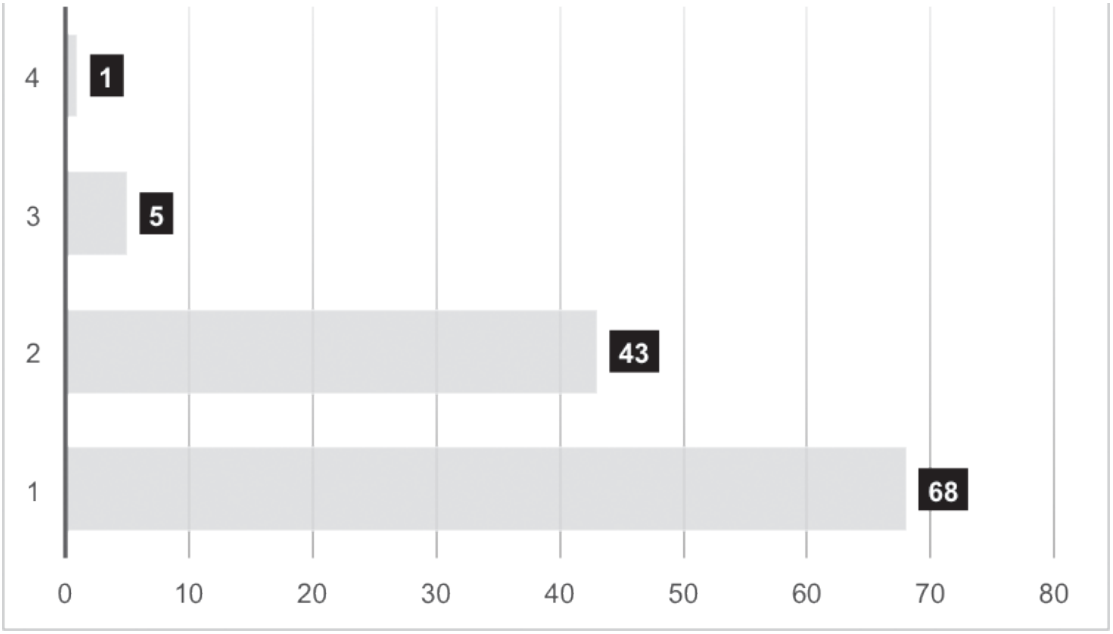

Fig. 5. Number of assessment occurrences on the Cormack-Lehane scale
Source: Own materials

Table.1. Subjective assessment of intubation difficulty

1	Definitely easy	50%
2	Rather easy	44%
3	I have no opinion	2%
4	Rather difficult	3%
5	Definitely difficult	1%

Source: Own materials

frequency. In the rest of the cases, other endotracheal tubes were used, e.g. the north polar or double-lumen tubes (here left-sided endobronchial), accounting for a total of just over 21%. During intubation in children, the type of tube was rarely changed. Figure 2 illustrates the use of different intubation tubes during this study.

In most cases, additional human resources or extra equipment were used during endotracheal intubation in paediatric patients. The most commonly chosen auxiliary equipment was the rigid guidewire. It was used not only because of the problems associated with the intubation procedure, but also because of the design of the tubes with which it is used (armored/double-lumen). A technique performed to aid the procedure was to move the trachea during intubation (Fig. 3). The use of more than one intervention occurred in 21 cases, or almost 18% of the study population.

The average age of the paediatric patients was approximately 6 years and 4 months. This means that the patients included in the study were pre-school or early school-age children. The mean weight of the patients enrolled in the study was 25.4 kg. Extreme values ranged from 2.7 kg to 104 kg. This is a fairly wide range of body weights, suggesting that the study group included children with different degrees of growth and physical development.

In the study group of paediatric patients, the route of intubation by mouth was clearly dominant. This method was chosen in the highest percentage of cases, i.e. out of the 117 patients studied, oral intubation was used in 113 cases. This indicates that nasal intubation is rarely used, which is consistent with clinical practice. Nasal intubation is usually preferred for neonates and premature infants, because of their specific anatomical features and the need to stabilise the endotracheal tube in the airway. Moreover, for operations of both the maxilla and mandible simultaneously, nasal intubation may be chosen to expose the surgical field better. In the study group, there were four cases of nasal intubation, accounting for 3.42% of the patients. Although this is a lower percentage than intubation through the mouth, it is worth underlining that this route of intubation still has its uses in certain clinical situations.

In the study group, craniofacial defects were recorded in 35 patients. The malformation syndrome, which presents with a recognizable pattern of congenital

anomalies that can also have an impact on the difficulty of intubation, occurred in four patients in the study. Among the cases studied, cleft palate was present in 29 patients, whereas cleft lip in 19 cases. In the study group, it was noted that craniofacial malformations with both cleft lip and palate occurred a total of 16 times. Craniofacial malformations with cleft palate occurred 13 times, while craniofacial malformations with cleft lip occurred 3 times. Additionally, in some cases, craniofacial defects with cleft lip and palate were accompanied by defect syndromes. Two such cases were noted. The first patient had tetralogy of Fallot and the other presented with Treacher Collins Syndrome. Craniofacial defects with cleft palate alone were accompanied by other disorders: in one patient a heart defect with Pierre Robin Syndrome and in the other Di George Syndrome. There were also postoperative conditions following cleft lip and/or palate for other cases of craniofacial defects. The presence of a palatal tumour was reported in one case. Among the examined cases there were also 3 newborns and 2 premature babies (Fig. 4).

Overall, 5 out of 117 cases had one or more difficulties, i.e. under 4.3% of the patients analysed. One patient had 2 difficulties, i.e. difficult airway (DA) and difficult mask ventilation (DMV). The above was the one with Treacher Collins Syndrome, hospitalised due to facial defects: cleft lip and cleft palate. An important point to be raised is that the difficulty of intubating patients with difficult airways is rated highest during the subjective assessment of intubation difficulty. Only a small percentage of intubation difficulties are due to the patients' anatomical structure, specifically their airway.

The Cormack-Lehane scale was used to assess 117 patients. The intubation time was measured and, after the procedure, each doctor performing the intubation made a subjective assessment concerning the difficulty of the case. Based on the above assessments, a score of 2 on the four-point Cormack-Lehane scale was obtained, with the highest score occurring once and the lowest 68 times (Fig. 5).

The average intubation time was less than 53 seconds, with extremes of 10 seconds for the fastest procedure and 5 minutes and 45 seconds for the longest. In most cases, intubation was rated as easy or rather easy on a five-point modified Likert scale (Table 1).

DISCUSSION

So far there have been many scientific studies on endotracheal intubation in pediatric patients. These studies have aimed to assess factors influencing intubation difficulties and to identify predictors of problems in children. The results of these studies provide important information on risk factors and potential strategies to prevent intubation difficulties [29-31]. Studies have shown that there is a diverse range of intubation problems in paediatric patients and that the factors impacting these may vary according to age, anatomical development, primary medical conditions and other factors. Studies on the assessment of intubation difficulties in children provide important clues for healthcare professionals helping to identify patients requiring special attention during endotracheal intubation [7, 24, 25, 29-31].

Research by Uchinami et al. has shown a correlation between success in the first intubation attempt using a classic laryngoscope and experience in anaesthesiology, whereas no such correlation was observed when a videolaryngoscope is used. In our own study, there is a correlation regarding intubation time and seniority combined with experience in anaesthesiology. In general, intubation time decreases with increasing experience [32].

Hansel et al. in their study on the basis of 61 studies with a total of 9883 participants were not able to link the relationship between intubation time and the Cormack – Lehane scale score due to the significant heterogeneity in the data. In contrast, our study showed a statistically significant relationship between the two variables, i.e. a moderate positive correlation between intubation time and the Cormack-Lehane scale score. This means that as the time of intubation increases, the rating of the difficulty in visualising anatomical structures also increases. The difference between intubation time and the Cormack-Lehane score is statistically significant. This is important because it suggests that there is a real relationship between the two variables and that the result is not due to chance [33].

In their study, Andruszkiewicz and Zawadka assessed the reliability of tests designed to identify difficulties during intubation. One of the conclusions drawn in the study is that prognostic tests, which are commonly used, are also unreliable. In their study, two tests had the highest diagnostic power: distance between incisors less than 3.5 cm and neck circumference greater than 42 cm [34]. Many different scales and combinations of scales are used to assess intubation difficulty. In their paper, Adnet et al. suggest the IDS scale which includes 7 factors and combines objective and subjective criteria. Nevertheless, despite a prospective evaluation of 311 prehospital and 315 hospital intubations, they suggest continuing the study, as enlarging the group may change the value of the results [35]. Nørskov et al. in their study focused on the accuracy of the prediction of difficult airway management by made by anaesthetists [36]. The results show how much work there still is in this sphere. It turns out that of the 3391 "difficult" intubations, as many as 93% were unpredicted, whereas only 25% were confirmed with previous assessment of a difficult intubation. With regard to difficult ventilation, the results were 94% and 22%, respectively. The conclusion is that one should always be prepared for difficult intubation. The studies available suggest that increasing the number of tests for predicting intubation difficulties may increase their overall diagnostic power. Unfortunately, this is too time-consuming to use in daily practice. In the study by Shulaman et al. on the use of the Bullard adult laryngoscope in children, no correlation was found between intubation time and the height, weight or age of the pediatric patient [37]. In our study, too, the age of the

pediatric patient was not shown to be related to intubation time and the subjective assessment of intubation.

CONCLUSIONS

The study which assessed the course and difficulty of endotracheal intubation in paediatric patients at the Institute of Mother and Child in Warsaw is an important step in improving medical care for these patients. The continuation of the research and the implementation of the results of this study may contribute to improving therapeutic outcomes and the safety of intubation per se, which is crucial for the health and life of paediatric patients.

It is recommended that the procedure for securing the airway should be standardized and a protocol for difficult intubation should be introduced, taking into account the difficulties and methods of action to support intubation.

It is recommended that intubation procedures should be adapted to the individual needs of patients, taking into consideration age, clinical condition and anatomy.

It is recommended that the established intubation protocols should be regularly evaluated and updated in accordance with the latest scientific findings and available tools and techniques.

It is recommended that adequate environmental conditions and infrastructure should be provided for endotracheal intubation (lighting, humidity, temperature, adjustability of the headrest, availability of gel positioners or their substitutes).

Moreover, the education of medical personnel is recommended. Programmes involving training, workshops and intubation skill improvement should be implemented to ensure the highest level of competence of the personnel involved in endotracheal intubation in paediatric patients. Staff knowledge, skills and experience have a direct impact on the safety and effectiveness of intubation procedures.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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The influence of occupational stress on the work of paramedics in relation to their workplace setting

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ABSTRACT

Aim: Paramedics are frontline professionals who have direct contact with patients. Their duties include patient care, stabilizing their condition, and communicating with patients' relatives, often having to deliver very difficult news. The aim of this article is to determine whether the place of employment affects the level of perceived stress, whether stress itself impacts the work of paramedics, and to identify the main sources of stress within this professional group.

Material and methods: The study was conducted using the CAWI method (Computer-Assisted Web Interviewing) in the form of an anonymous online survey. It was distributed to 70 actively working paramedics employed in various healthcare settings in Poland. The questionnaire included 25 questions covering demographics, sources of stress, its consequences, and coping strategies. Data were collected between February and April 2025 and analyzed using SPSS and Excel. The level of statistical significance was set at 0.05.

Results: The average stress level in the group was 5.34 (SD = 2.0). Employment setting had limited influence on stress, although respondents from emergency departments and medical dispatch centers reported slightly higher levels. The most frequent stressors were aggression from patients or their families (70%) and cases involving children (54.3%). Coping strategies most often chosen included physical activity (52.9%) and talking to relatives (71.4%). Only 28.6% reported having access to support at work.

Conclusions: Stress is present and noticeable in the workplace of paramedics. Unfortunately, despite this awareness, employers do not provide adequate support to help manage it effectively.

KEY WORDS

emergency medical services, mental health, working conditions

INTRODUCTION

Stress is a daily part of paramedic work. The World Health Organization (WHO) defines stress as a "state of worry or mental tension caused by a difficult situation," which is a normal human response [1]. Without adequate support, stress may lead to ineffective or harmful coping strategies. This was observed in Poland, where the ALCOVID study reported increased alcohol consumption among quarantined physicians during the pandemic [2]. Long-term, such behavior can lead to addiction. Similarly, Singh et al. found that most medical students used alcohol, tobacco, or psychoactive substances to manage stress [3].

WHO estimates that 15% of working adults face workplace-related mental health issues. A 2022 report noted that perceived pressure, poor work environments, and lack of support harm employees' mental health. WHO stresses that organizational changes can improve mental health [4]. Similar findings come from international EMS studies [5].

According to ICD-10 (code Z73.0), burnout is a "state of vital exhaustion" [6]. Though general, this classification shows that working conditions affect mental health. In 2019, WHO added burnout to ICD-11, defining it as a syndrome from chronic unmanaged workplace stress. Main symptoms include emotional exhaustion, negative attitudes toward work, and reduced effectiveness. Paramedics constantly interact with patients and families, often in difficult conditions [7]. Research in Norway by Sterud et al. shows paramedics face high stress risks, mainly from overtime and lack of workplace support [8]. Iordache et al. highlight time pressure and trauma exposure as key stressors [9]. A Polish study using the Oldenburg Burnout Inventory found significant burnout among paramedics and stressed the need for support measures [10].

The COVID-19 pandemic worsened these issues. Spychała, Piwowarska, and Piekut reported that 49.4% of paramedics experienced high stress during the pandemic, with over 11% reporting very high levels. Most had contact with infected patients, and many contracted COVID-19 themselves, likely intensifying stress [11]. Ziarko et al. found depression and elevated stress were common, especially in those treating COVID-19 patients [12].

During the pandemic, stress, depression, and the use of psychoactive substances were significant risk factors for health deterioration, including life-threatening conditions, across all occupational groups [13, 14].

Long-term stress can lead to burnout and decisions to leave the profession. Crowe et al. showed a clear link between burnout and intentions to quit healthcare jobs [5]. Beldon and Garside noted that paramedics are front-

line workers exposed to stressors promoting burnout and highlighted the importance of continuous psychological support [15].

Unlike police or firefighters, paramedics often lack immediate psychological support after traumatic events. They must process incidents alone and be ready for the next call. WHO states stress affects both body and mind. Moderate stress can be helpful, but excessive stress leads to health problems like pain, substance use, and sleep issues [16].

In crises, WHO recommends physical and psychological support, debriefing, and training to reduce burnout and errors. Stress sources include not only incidents and patient conditions but also reactions from families, witnesses, work environment, and teams [7].

Common tools like PSS-10, Maslach Burnout Inventory, and Coping Inventory for Stressful Situations measure stress in research [17–19]. This study used a custom questionnaire tailored to paramedics' specific work conditions, addressing daily challenges across different workplaces.

The aim was to assess how the workplace affects perceived stress and identify common stressors among 70 active paramedics. The online survey data help understand daily realities and highlight areas needing organizational and psychological support.

AIM

The study aimed to examine how perceived stress levels affect paramedics' professional functioning depending on their workplace. It focused on identifying common occupational stressors and whether high stress influences career decisions, such as job changes or leaving the profession.

Given paramedics' constant exposure to stress, this topic has practical importance. Understanding stress mechanisms can improve working conditions and support systems for this group.

The hypotheses were:

1. Employment place significantly relates to perceived stress levels.
2. Main stressors are contact with aggressive patients, time pressure, and mass incidents.
3. Coping strategies do not differ significantly by workplace.
4. High stress levels affect decisions to change jobs or leave the profession.

MATERIALS AND METHODS

The study was conducted following the Declaration of Helsinki and approved by the Ethics Committee of the Medical University of Warsaw (protocol AKBE/41/2025;

Table 1. Workplace of the respondents

Workplace	n	[%]
Medical dispatch center	1	1,4
Hospital admission room	5	7,1
Air Ambulance Service (HEMS)	2	2,9
Intensive Care Unit (ICU)	1	1,4
Private medical company	13	18,6
Hospital Emergency Department (ED)	25	35,7
Medical transport	1	1,4
Military / uniformed services	4	5,7
EMS team in a large city (>100,000 inhabitants)	10	14,3
EMS team in a small town (<100,000 inhabitants)	8	11,4
Total	70	100

n – numer of responders; [%] – percentage of the sample

Source: Own materials

Table 2. Average stress level (1–10 scale) among employees in private medical companies, hospital emergency departments (ED), and emergency medical services (EMS)

Workplace	M	SD	min	max
Private medical company	5,54	2,76	2	10
Hospital Emergency Department (ED)	5,40	1,83	2	9
Emergency Medical Service team (EMS)	5,17	1,65	2	7

M – mean; SD – standard deviation; min – minimum; max – maximum

Source: Own materials

approval date: 24 February 2025). It took the form of an anonymous online survey via Google Forms from February to April 2025. Participation was voluntary and anonymous.

The study group included 70 actively working paramedics employed across Poland. Inclusion criteria were professional qualifications and current employment in emergency medical services (e.g., Emergency Department, EMS Team, private company, Air Ambulance). The purposive, non-probabilistic sample was recruited through thematic EMS groups.

A custom 25-question questionnaire covered demographics (gender, age, workplace, experience, education) and specific paramedic work stressors. Standardized tools like PSS-10 or MBI were not used, as the goal was to reflect the unique Polish paramedic context. The questionnaire, developed from literature review and practical insights, contained mostly closed-ended questions and one numerical scale, organized into four sections: demographics, stress level and sources, effects, and coping strategies. Respondents' demographic and professional data are detailed in the Results section.

Data were analyzed using SPSS. Descriptive statistics (means, SDs) and Pearson's chi-square test of independence were used. Stress levels were compared between professional groups, and links between stress and career decisions examined.

RESULTS

The aim was to determine the stress level among paramedics depending on their place of employment and to analyze which situations are the most stressful. Seventy paramedics from various locations in Poland participated. The gender distribution was similar-38 men (54.3%) and 32 women (45.7%). The dominant group was people under 35 years old (77.1%) and with less than 5 years of professional experience (68.6%). Most respondents worked in the Emergency Department (35.7%) (Table 1).

Table 3. Frequency of stress experienced depending on the place of employment

	Workplace					
	Private companies		ED		EMS	
Stress at work	n	[%]	n	[%]	n	[%]
Never	1	7,7	0	0,0	0	0,0
Rarely	6	46,2	9	36,0	10	55,6
Often	4	30,8	16	64,0	8	44,4
Always	2	15,4	0	0,0	0	0,0
Total	13	100	25	100	18	100

n – numer of responders; % – percentage of the group

Source: Own materials

Table 4. Sources of stress indicated by the respondents

Occupational stressors	n	%
Lack of proper equipment	26	37,1
Lack of stability – frequent management changes	1	1,4
Team conflicts	30	42,9
Contact with aggressive patients/family members	49	70,0
Mobbing (workplace bullying)	1	1,4
Low salary	15	21,4
Working with children	38	54,3
Time pressure	18	25,7
Mass casualty incidents	24	34,3
Poor work organization	25	35,7

n – numer of responders; % – percentage of the sample

Source: Own materials

The first hypothesis assumed that the place of employment affects the level of perceived stress among paramedics. Table 2 presents the mean values of stress intensity rated on a scale from 1 to 10 in the group of people working in private medical companies, in hospital emergency departments, and in emergency medical teams. Other workplaces were excluded from the analysis due to the small number of respondents working in those places.

Based on the value of the one-way analysis of variance, no statistically significant differences were found between the compared groups in terms of stress intensity, $F(2,53)=0.14$, $p>0.05$, thus no results confirming hypothesis 1 were obtained. Table 3 presents the distribution of the frequency of experiencing stress in groups distinguished by workplace.

Based on the value of the independence test $\chi^2(6)=12.88$, $p<0.05$. Frequent stress was reported by 64% in EDs *vs.* 55.6% in EMS and 30.8% in private firms, suggesting workplace-related variation (Fig. 1).

The next hypothesis concerned the main sources of stress. It was assumed that the most frequently indicated factors would be contact with aggressive patients, time pressure, and participation in mass casualty incidents. Table 4 presents the distribution of sources of stress at work indicated by the respondents.

Figure 2 shows the percentage distribution of stress sources reported by respondents, ranked from most to least frequent.

Aggressive patients, pediatric cases, and team conflicts were the top stressors. Equipment issues, poor organization, and mass incidents followed. Time pressure and low pay were less frequent stressors.

The third hypothesis assumed no significant differences in coping strategies between paramedics employed in different workplaces. Table 5 presents the distribution of coping strategies used by respondents working in private medical companies, hospital emergency departments, and emergency medical teams. The summary is supplemented with the values of the independence test χ^2.

No statistically significant relationships were found between the workplace of the respondents and the coping strategies used, which confirms the third hypothesis. The most frequently indicated coping strategies were physical activity and developing hobbies.

Table 6 presents the distribution of coping strategies after the end of a shift among respondents from private companies, ED, and EMS, along with χ^2 test results. No statistically significant relationships were found between workplace and chosen strategies (all $p \geq 0.05$), confirming hypothesis 3. The most common strategies were physical activity, hobbies, and talking with family or friends. The most frequently indicated strategies were physical activity, hobbies, and talking with family and friends.

The last hypothesis concerned the impact of stress on decisions to change jobs or leave the profession. Table 7 shows how frequently respondents perceived stress as having a negative effect on their physical or mental health. Most declared experiencing such effects at least occasionally, with over one-third reporting it of-

Table 5. Coping strategies used during work by employees of private medical companies, emergency departments, and EMS teams

	Workplace							
	Private companies		ED		EMS			
Coping strategies	n	[%]	n	[%]	n	[%]	χ2	p
Physical activity	10	76,9	13	52,0	12	66,7	2,46	0,292
Time management and planning	5	38,5	12	48,0	6	33,3	0,98	0,613
Practicing mindfulness	0	0,0	1	4,0	1	5,6	0,70	0,704
Developing hobbies	7	53,8	13	52,0	9	50,0	0,05	0,977
Cognitive-behavioral techniques	0	0,0	4	16,0	1	5,6	3,06	0,216
Relaxation techniques	2	15,4	6	24,0	3	16,7	0,55	0,759
Psychological therapy	1	7,7	6	24,0	3	16,7	1,58	0,455
Avoiding excessive stressors	0	0,0	7	28,0	5	27,8	4,62	0,099
Alcohol use	1	7,7	1	4,0	3	16,7	2,10	0,351
Psychoactive substance use	0	0,0	3	12,0	0	0,0	3,93	0,140
Social support	3	23,1	9	36,0	3	16,7	2,11	0,348
Healthy lifestyle	7	53,8	10	40,0	3	16,7	4,91	0,086

n – numer of responders; % – percentage of the group; χ2 – chi-square test value for df = 2 for all comparisons; p – statistical significance level

Source: Own materials

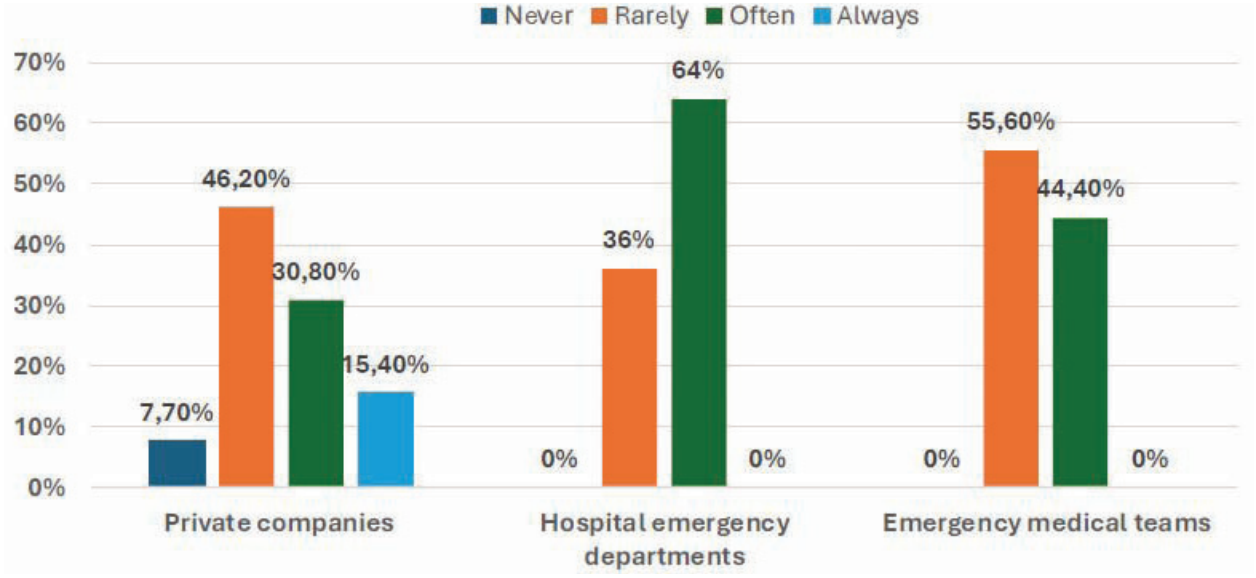

Fig. 1. Reported stress level depending on workplace

Source: Own materials

Fig. 2. Percentage distribution of reported sources of stress

Source: Own materials

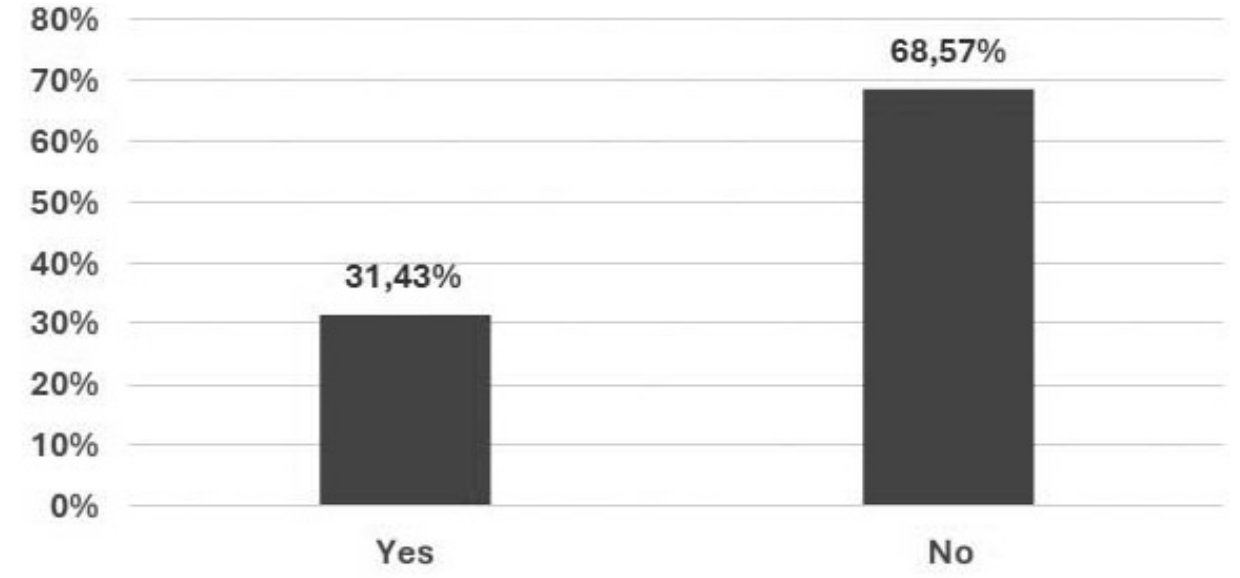

Fig. 3. Impact of stress on professional decisions (e.g., changing workplace, resignation)

Source: Own materials

ten. These findings suggest that stress may influence job satisfaction and career retention.

Twenty-two respondents (31.4%) admitted that stress influenced their professional decisions (e.g., changing jobs or resignation) (Fig. 3). The majority of respondents, i.e., 49 people (68.6%), did not notice such an impact, thus no results confirming the last hypothesis were obtained.

Table 6. Coping strategies used after work shifts by employees of private medical companies, emergency departments, and EMS teams

	Workplace							
	Private companies		ED		EMS			
Coping strategies	**n**	**[%]**	**n**	**[%]**	**n**	**[%]**	**χ2**	**p**
Physical activity	8	61,5	12	48,0	7	38,9	1,55	0,460
Passive rest	0	0,0	0	0,0	1	5,6	2,15	0,341
Hobbies	7	53,8	7	28,0	8	44,4	2,69	0,260
Social media	1	7,7	0	0,0	0	0,0	3,37	0,186
Watching series	0	0,0	0	0,0	1	5,6	2,15	0,341
Cigarettes	1	7,7	4	16,0	3	16,7	0,61	0,739
Talking to family/friends	8	61,5	23	92,0	14	77,8	5,14	0,077
Sleep	1	7,7	0	0,0	0	0,0	3,37	0,186
Listening to music, going to the cinema	0	0,0	0	0,0	1	5,6	2,15	0,341
Taking a nap	0	0,0	1	4,0	0	0,0	1,26	0,532
Trying not to bring stress home	1	7,7	0	0,0	0	0,0	3,37	0,186
Avoiding the topic/work	4	30,8	6	24,0	1	5,6	3,58	0,167
Alcohol	1	7,7	4	16,0	3	16,7	0,61	0,739

n – numer of responders; % – percentage of the group; χ2 – chi-square test value for df = 2 for all comparisons; p – statistical significance level

Source: Own materials

Table 7. Perception of stress-related negative effects on physical or mental health

Perceiving the negative effects of stress	n	[%]
No	10	14,3
Yes, occasionally	35	50,0
Tak, often	25	35,7
Total	70	100

n – numer of responders; [%] – percentage of the sample

Source: Own materials

Table 8. Perceived impact of stress on personal life

Perceived impact of stress on personal life	n	[%]
Definitely not	2	2,9
Rather not	19	27,1
Rather yes	33	47,1
Definitely yes	16	22,9
Total	70	100

n – numer of responders; [%] – percentage of the sample

Source: Own materials

Table 9. Distribution of support in stressful situations at the workplace

Support in stressful situations	n	[%]
No	40	57,1
Yes	18	25,7
I don't know	12	17,1
Total	70	100

n – numer of responders; [%] – percentage of the sample

Source: Own materials

Table 10. Respondents' answers to the question about choosing the paramedic profession again, knowing the current level of stress associated with the job

Choosing the paramedic profession again	n	[%]
Definitely not	3	4,3
Rather not	8	11,4
Rather yes	24	34,3
Definitely yes	35	50,0
Total	70	100

n – numer of responders; % – percentage of the sample

Source: Own materials

Table 8 presents the distribution of perceived impact of stress on personal life among the respondents. Most respondents noticed the impact of stress on personal life, i.e., answered "rather yes" or "definitely yes." In total, this was 70.0% of the respondents.

In addition to the stated hypotheses, to better understand how paramedics cope with occupational stress, the study also asked about participation in stress management training and the presence of support in the workplace. The study showed that twenty-one respondents (30.0%) participated in stress management training. However, more than half (57.1%) stated that their workplace did not provide support in stressful situations (Table 9).

Due to the exposure to stress in the paramedic profession, study participants were also asked whether, knowing the current degree and impact of stress, they would choose this profession again. The obtained answers are presented in Table 10.

Most people would choose the paramedic profession again, even with the awareness of the level of stress associated with this job. The answers "rather yes" or "definitely yes" were given by 84.3% of respondents.

DISCUSSION

The study assumed that the place of employment of paramedics affects their perceived level of stress. Average stress was 5.34 – highest in private companies, lowest in EMS teams. Stress frequency, though not intensity, varied across workplaces. In each of the analyzed groups, the answer "often" was given as the frequency of perceived stress-private company 30.8%, ER 64%, EMS 44.4%. In the study by Nowakowska conducted among emergency department employees, it was also shown that the studied group experiences stress more intensely and more often than employees of other medical facilities. This is mainly related to feelings of emotional exhaustion, depersonalization, and a low sense of achievement. Thus, the workplace matters less than the job's nature in a given setting.

Another assumption was that the most common stressful situations would be: contact with aggressive patients, time pressure, and mass casualty incidents. The analysis only partially confirmed the hypothesis. The most stressful situations involved aggression (70%), followed by pediatric cases. Mass casualty incidents and time pressure were only in sixth and seventh place on the list, respectively. This may be because such cases are rare; most calls involve routine health issues. However, there is no doubt that aggression from patients and their environment is present [20]. This is confirmed by the results of the study by Pękala et al., who showed that the form of aggression paramedics are exposed to is both physical and verbal. The mentioned study emphasized that such situations negatively affect the well-being of medical staff [21]. Similar observations can be found in the work of Lickiewicz et al., who studied how medical students perceive aggression towards medical personnel. Aggression from patients triggers tension, fear, irritability, and loss of control. As such experiences are prolonged, the quality of healthcare services provided decreases. The study showed that the problem of aggression is also noticed by students undergoing professional internships during their education [22].

Pediatric cases, though less frequent, often evoke stronger fear and tension. This results from the need to

use a completely different approach than with adults, and an additional difficulty may be the presence of a parent whose emotions and behavior do not always support the course of the intervention.

The third hypothesis concerned the lack of differences in coping strategies among the studied individuals. The analysis confirmed that regardless of the place of employment, paramedics choose similar ways of coping with stress. The most preferred way of relieving stress was definitely physical activity-private company 76.9%, ER 52%, EMS 66.7%. After shifts, some groups favored talking over physical activity. In the group of private company employees, both methods received the same percentage of votes (61.5% each), but among paramedics working in ERs, as many as 92% indicated talking with loved ones, while only 48% chose physical activity. In EMS, talking was also chosen more often (77.8%) than physical activity (38.9%). After work, paramedics often prefer rest with loved ones over further exertion.

Additionally, coping strategies may largely depend on one's personality, available forms of support, and, above all, one's approach to a particular situation. The work environment may impose certain ways due to group pressure, but the final decision to follow them remains with the individual.

Similar conclusions were reached by Żurowska-Wolak et al., who confirmed among 122 paramedics from Krakow that both constructive and non-constructive methods of coping with stress appear. They were independent of the place of employment, but the vast majority of respondents, as many as 64%, chose constructive techniques such as physical activity or relaxation techniques [23]. WHO's "Doing What Matters" guide promotes simple stress-coping techniques for anyone, not just medics [24].

The last hypothesis concerned the impact of perceived stress on professional decisions, such as considering changing jobs or leaving the profession altogether. Although only about one-third of paramedics admitted that stress directly affected their professional lives, a much more worrying fact is that as many as 70% of respondents notice its negative effects in everyday life. On the one hand, this may indicate their self-awareness-if they know that stress affects them, perhaps it is easier for them to control emotions and avoid transferring tension from work to home. On the other hand, it should be remembered that paramedics are also ordinary people-they are not always able to maintain full distance from what they experience professionally. Intense stress may lead to arguments or blaming loved ones unrelated to the cause. Sometimes, even a trivial situation or minor family conflict is enough for accumulated work-related emotions to be released. This often happens in a sudden and disproportionate manner to the actual problem.

Fewer than 30% reported workplace support. Such low availability of help, especially in a profession exposed to constant stress, definitely works to the disadvantage of employees. A brief talk could help after a hard shift, but such opportunities are rare.

A similar study was conducted by Buljan et al., who, after examining 456 paramedics, found that the most significant factors affecting perceived stress are: a sense of responsibility, uncertainty about the work system, and psychological workload. The mentioned study also showed that especially among paramedics working in EMS, perceived stress had a direct impact on the occurrence of burnout symptoms [25].

Żurowska-Wolak et al. found that people who experience burnout symptoms are much more likely to feel reduced job satisfaction, exhaustion, and fatigue. In the long term, all these things can lead to thoughts of leaving the profession [23].

Despite all these difficulties, pressure, and daily challenges, it is very positive that over 75% of paramedics would choose this profession again. This is truly uplifting. It means that despite stress, fatigue, and sometimes ungrateful situations, there are still people who want to help and be part of the healthcare system. Thanks to these people, the system has the greatest strength.

The purposive sample, mostly younger paramedics with limited experience, limits generalizability. Demographic factors like age, gender, or experience were not controlled in the analysis. This may affect the level of perceived stress and professional decisions. Younger paramedics are still adapting to the system and pace of work.

On the other hand, it is worth noting that this limitation can also be treated as a valuable conclusion. If even among such a young group there was a clear tendency to consider leaving the profession due to stress, it would mean a real threat to the future of medical staff. Early lack of support may cause rapid burnout and staff turnover. This could worsen staffing shortages.

If they are not provided with adequate support – such as access to a psychologist, training, or space to relieve tension-the system will become even more overloaded. Soon, mostly older staff will remain, risking quality declines from overload.

The second limitation of the study was the use of a proprietary questionnaire instead of ready-made standardized tools. Due to the lack of prior official confirmation of the validity and reliability of this survey, the obtained results cannot be compared with the results of other studies. However, the use of this form was not accidental. Scales such as PSS-10 or MBI do not directly refer to the realities of paramedics' work, especially considering the variety of workplaces and specific stressful situations that occur in this profession. By creating a proprietary questionnaire, it was possible to obtain more detailed and practical information based on the real experiences of paramedics, which could not be described using ready-made forms.

At the beginning of this year a tragedy occurred in Siedlce [26]. During a rescue operation, an emergency medical team was attacked by a patient, as a result of

which one crew member died in hospital from injuries sustained. The whole matter was reported on one of many websites. Shortly after the incident, the newly established National Chamber of Paramedics began negotiations with the government to increase the safety of medical personnel. After negotiations, changes were published that are to be introduced at the beginning of 2026. These include: the introduction of 3-person EMS type P teams, self-defense training, provision of psychological support, and an educational campaign to raise respect for paramedics [27, 28].

In this profession, it is impossible to completely eliminate certain situations. It is never possible to predict what situation will be encountered, whether upon arrival at the scene or directly during patient care in various places. Safety training and equipment can improve paramedics' sense of security. This will result in a reduction in perceived stress in such situations, making their work more effective.

CONCLUSIONS

The study shows that while the place of employment does not significantly affect average perceived stress levels, the frequency of stress depends largely on the work environment. The most common stressor was contact with aggressive patients and their families, impacting both personal and professional life. Despite work difficulties, most respondents would choose this profession again. These findings highlight the need for improved psychological support and stress coping training for this group. Future research should use standardized tools like PSS-10 or MBI and include a larger, more diverse sample to enhance validity and comparability.exercises, such as the one described for the purpose of this paper.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

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Emergency motorcycles in prehospital care: A comparative analysis with traditional ambulances in Poland

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ABSTRACT

The Polish State Emergency Medical Services (EMS) system is facing a growing operational crisis. In many regions, particularly rural and mountainous areas, there is a visible shortage of EMS teams, limited ambulance availability, and difficulties in reaching patients in a timely manner. Urban traffic congestion, long distances to hospitals, and the lack of rapid alternatives to traditional emergency vehicles negatively impact intervention effectiveness. In response to these challenges, the integration of emergency motorcycles as a supplementary intervention tool is being considered. This study analyzes the role of emergency motorcycles in prehospital interventions, examining their technical characteristics, operational capabilities, and comparing them to traditional ambulances in terms of equipment, response time, patient transport capacity, and costs. The study also considers current legal regulations, including amendments to the State Emergency Medical Services Act, which for the first time formally regulate the use of motorcycles in this context. While findings suggest that emergency motorcycles could significantly improve the response speed of the State EMS in selected situations, limitations include their reduced medical equipment capacity, lack of patient transport functionality, and the systemic strain caused by understaffing and a high volume of non-urgent EMS calls. These constraints should be taken into account when evaluating their broader implementation.

KEY WORDS

emergency medical services, emergency motorcycle, prehospital intervention

INTRODUCTION

The emergency medical services system in Poland faces numerous challenges, the most impactful being the limited number of EMS teams, difficulties in accessing aid in rural, mountainous, and other hard-to-reach locations. Moreover, traffic congestion, long distances to hospitals, and overburdened medical services contribute to delayed responses, which in critical cases can be a matter of life and death [1]. These delays are further exacerbated by frequent difficulties in forming emergency corridors, especially in dense urban traffic. Emergency vehicles, while essential, do not always fulfill their role in situations where every second counts [2]. In response to these issues, solutions to support conventional ambulances are being sought which should be modern and rapid, in terms of mobility and response time.

Emergency motorcycles, utilized as privileged vehicles in the EMS system in urban areas where heavy traffic is a problem, appear to be a promising alternative [3]. The use of motorcycles in EMS is not entirely new in Poland. They have been employed seasonally and in large cities, but the 2025 amendment to the State Emergency Medical Services Act has now established a formal legal framework for their broader and systematic implementation. Given the increasing demand for faster and more mobile intervention methods, this study analyzes the role of emergency motorcycles in the Polish EMS system.

AIM

The aim of this study is to assess the role of emergency motorcycles as a complementary element in the Polish Emergency Medical Services (EMS) system, especially in light of the 2025 amendment to the EMS Act, which legally recognizes their use.

MATERIAL AND METHODS

The analysis includes a review of scientific literature (2016–2025), legal regulations, and case examples from Polish pilot programs. Key aspects explored are response times, operational costs, equipment capabilities, and

limitations such as the inability to transport patients.

In addition, the study considers clinical indications for dispatch, integration with EMS systems, safety risks for operators, and the specific competencies required for motorcycle paramedics. Public and professional perceptions are also discussed.

The findings aim to support the informed implementation of emergency motorcycles in scenarios where speed and accessibility are critical- such as urban traffic, large events, or hard-to-reach locations.

REVIEW

ORGANIZATION OF THE EMERGENCY MEDICAL SERVICES SYSTEM IN POLAND

The State Emergency Medical Services (pol. System Państwowego Ratownictwa Medycznego PMR) in Poland is one of the key pillars of public healthcare, responsible for providing assistance in cases of sudden medical emergencies [4]. Its operation is regulated by the State Emergency Medical Services Act of September 8, 2006, which defines the scope of activities, organizational structure, and conditions for prehospital care [5]. The aim of the system is to deliver fast and professional medical assistance in emergencies while maintaining safety standards and accessibility of services.

The PRM structure includes medical dispatch centers, EMS teams, hospital emergency departments, Air Ambulance Services, and cooperating entities such as the State Fire Service, Police, Mountain Volunteer Rescue Service, and Water Volunteer Rescue Service [6]. Each of these components plays a significant role in the emergency response chain, and their coordinated actions determine the system's overall effectiveness. Critical role play EMS teams, which are operating around the clock and are categorized into basic, advanced, and specialized teams [7]. Basic teams consist of at least three members, including one person authorized to perform emergency medical procedures (a nurse or paramedic) and two rescuers qualified in advanced first aid. These teams handle prehospital interventions in cases not requiring advanced medical supervision and are the most frequently deployed units. Advanced teams comprise at least three authorized medical personnel, including a nurse or paramedic with specialized qualifications, enabling them to manage more critical cases. Specialized teams have the broadest scope of competence and may consist of two or three members, depending on the organizational model.

Teams operating in a "rendez-vous" (R-V) model coordinate with other emergency units at the scene, such as fire departments or basic EMS teams [7]. Mobile Intensive Care teams provide full intervention capabilities comparable to prehospital intensive care. Each of these structures performs an important task in the PRM system, ensuring the availability of an appropriate level of medical assistance depending on the scale and nature of the incident.

In the event of a medical emergency, the first response link is the medical dispatcher, who assesses the situation via telephone and assigns an intervention priority level [8]. Teams may be dispatched with a first (immediate life-threatening condition), second (serious but not immediately life-threatening), or third (stable condition, often not requiring urgent intervention) priority [8]. Dispatchers use modern location and resource management systems to optimize team deployment and reduce response times.

A fundamental aspect of PRM operations is the strategic placement of EMS teams to guarantee urban response times of no more than 8 minutes and rural response times of no more than 15 minutes [8]. However, in practice, achieving these targets is often hindered by staffing shortages, equipment deficits, geographical or logistical challenges, particularly in sparsely populated or difficult terrain.

The efficiency of PRM depends on available resources, organizational effectiveness, and the ability to adapt to changing epidemiological and demographic conditions. Therefore, continuous monitoring and improvement of the system are required, which include the exploration of modern solutions such as emergency motorcycles. In the long run leading to significant enhanced accessibility and reduced response times for EMS teams.

OPERATIONAL CHALLENGES OF THE STATE EMERGENCY MEDICAL SERVICES SYSTEM IN LIGHT OF STATISTICAL DATA

The State Emergency Medical Services (EMS) system in Poland, despite its important role in the healthcare structure, faces numerous organizational, logistical, and staffing challenges. Growing demand for emergency care, due to an aging population, increased risk of lifestyle diseases, and dynamic changes in environmental conditions, pressure the ineffective EMS system. An analysis of statistical data from recent years reveals the most significant operational difficulties affecting the capability of prehospital care.

One of the many issues is the insufficient number of EMS teams relative to the volume of emergency calls. According to data from the Ministry of Health, in some regions, the number of EMS dispatches per 10,000 inhabitants significantly exceeds the national average, leading to prolonged response times, seen particularly in rural and mountainous areas [9]. In many cases, the available teams are already engaged in interventions, forcing newly reported emergencies to wait for resources to become available [9]. Meanwhile, response time is one of the most important factors affecting patient outcomes.

Another challenge is the shortage of qualified medical personnel [9]. Staffing gaps affect both paramedics and EMS physicians. The situation is exacerbated by high psychophysical demands, work overload, and insufficient compensation, which drive many specialists to migrate abroad or to the private sector [10]. The report "Health and Healthcare in 2023" noted that despite a slight increase in the number of paramedics (1.2% compared to 2022), there remains a concerning downward

trend in the number of EMS physicians and nurses [9]. In 2023, the number of nurses decreased by 2.6%, while the number of physicians dropped by 9.0% compared to the previous year, limiting the system's operational capacity. Staff shortages are the most acute in smaller towns and areas with dispersed populations, where recruitment and retention of medical personnel are more challenging.

Infrastructure and equipment issues also pose significant difficulties. Despite modernization efforts, many ambulances in Poland exceed their recommended service life, increasing the risk of breakdowns and compromising patient transport safety. Data from 2023 indicate that Poland had approximately 1,636 EMS teams, including 1,302 basic teams and 315 specialized teams [11, 12]. While this reflects a gradual expansion of the EMS system compared to 2022 [11], some regions still face difficulties in accessing adequately equipped EMS bases and lack modern communication systems and mass-casualty incident management tools.

Another growing problem is the unjustified use of EMS resources. Statistics show that a significant percentage of dispatches involve cases that do not qualify as medical emergencies [13]. In 2022, there were 2.1 million unjustified EMS calls, accounting for 40% of all reports [13]. Such calls not only burden the system but may also delay responses to patients in genuine need of immediate intervention. Some cases could have been managed through primary care or medical consultation, but due to limited access to these services, patients resort to emergency numbers.

Finally, ensuring timely arrival at the scene remains a major challenge. According to government data, the maximum response time for ambulances is 8 minutes in urban areas and 15 minutes elsewhere, but these targets are not always met [9, 14]. Traffic congestion, poor road conditions, and the lack of priority infrastructure further complicate the situation. Response times are most problematic during tourist seasons, in mountainous regions, and in areas with limited transport access. In 2023, data from regional authorities showed that median response times were exceeded in all voivodeships, with the highest delays recorded in Warmian-Masurian (16 min. 31 s.) and Lower Silesian (21 min. 20 s.) voivodeships in rural areas [9].

The increasing number of calls, staffing shortages, equipment issues, and system misuse create a complex web of challenges requiring both legislative and operational solutions. In the context, alternative intervention methods, which includes emergency motorcycles, gain interest, as they could improve response times and alleviate pressure on traditional ambulance teams.

COMPARATIVE ANALYSIS OF EMERGENCY MOTORCYCLES AND TRADITIONAL AMBULANCES

Modern emergency medical services face numerous challenges, including rising call volumes, system overload, and difficulties in accessing patients in congested or hard-to-reach locations. In response, alternatives and supplementary transport methods for rescuers and medical equipment are being explored. One of the solution is the emergency motorcycle, a specially adapted two-wheeled vehicle for medical interventions within the State EMS system [2]. Although its use in Poland remains limited, many European countries, such as the UK, Portugal, and the Czech Republic, have long employed emergency motorcycles as effective tools in prehospital care [1, 15–17].

The integration of emergency motorcycles into the EMS system necessitates an analysis of their efficiency compared to traditional ambulances. While both serve rescue functions, their characteristics, operational capabilities, and applications are significantly different. The following comparison examines key factors influencing prehospital intervention effectiveness.

Response time

One of the most frequently cited advantages of emergency motorcycles is their ability to reach the scene quickly. Especially in urban areas where traffic congestion hinders traditional ambulances. Their agility, ability to bypass traffic, and ease of maneuvering in tight spaces can reduce response times by several minutes. In life-threatening situations, such as cardiac arrest, this difference decide about patient survival. Moreover, their rapid arrival often enables treatment initiation within the "golden hour," which is critical in minimizing the risk of long-term complications or death.

A 2021 study by Cambridge University Press analyzed 271 interventions by motorcycle EMS teams over two years. The average dispatch-to-departure time for motorcycle was 0.59 minutes, a significantly shorter time response than for traditional EMS teams (1.45 minutes, $P = 0.004$). Similarly, the average on-scene arrival time was 6.12 minutes for motorcycles versus 9.10 minutes for ambulances. These results suggest that emergency motorcycles can effectively complement traditional EMS in urban conditions.

Available medical equipment

Due to limited cargo space, emergency motorcycles carry a restricted range of medical supplies [18–20]. Their function dictates differences in equipment compared to ambulances.

Emergency motorcycles are specialized vehicles designed for rapid response, playing important role in congested or inaccessible areas [18]. Their equipment includes essentials for prehospital care, such as: automated external defibrillator (AED), airway management tools, active and passive oxygen therapy kits, cervical collars, limb immobilization devices [21]. Additionally, they carry trauma dressings, burn treatment supplies, and anti-shock equipment for basic field care. For vital sign monitoring, they are equipped with diagnostic tools like pulse oximeters, glucometers, and blood pressure monitors.

In contrast, ambulances, designed for patient transport and their health support, meet broader equipment requirements [22]. Their standard inventory includes:

manual defibrillators with ECG monitoring, transport ventilators, intubation and mechanical ventilation kits, infusion pumps, medical suction devices, emergency medications, stretchers, spine boards, and patient evacuation systems [22]. Contrary to motorcycles, ambulances enable advanced resuscitation and therapeutic procedures, ensuring continuity of care during transport.

The equipment of a rescue motorcycle, although limited compared to a standard ambulance, enables effective emergency care in a range of life-threatening conditions. The use of a pulse oximeter, glucometer, and blood pressure monitor allows for fast assessment and monitoring of vital parameters in patients suspected of hypoglycemia, hypertensive crisis, or perfusion disorders. The motorcycle paramedic can stabilize the patient before the arrival of a transport team, initiating life-saving treatment in accordance with current prehospital medicine guidelines.

It is worth emphasizing that a rescue motorcycle does not replace a traditional ambulance but rather complements it. Its primary role is to initiate life-saving procedures, assess the situation at the scene, and relay information to the medical dispatch center, which can streamline further logistical actions. In practice, it is often the case that the motorcycle arrives first, stabilizes the patient, and then hands over care to the arriving ambulance, which conducts further diagnostics and transports the patient to the hospital. Since 2025, a clear decision-making algorithm has been established, guiding dispatchers on when to prioritize the deployment of a motorcycle in a given situation, ensuring that the right resource is allocated to the emergency at hand.

The AED is one of the most important medical devices that can be safely and effectively transported by a paramedic on a motorcycle. Research conducted in Thailand in 2022 indicates that a motorcycle equipped with an AED has a significantly shorter dispatch time (0.44 min) and call-to-arrival time (7.20 min) compared to traditional ambulances (1.42 min and 9.25 min, respectively) [2]. Faster arrival at the scene allows for earlier initiation of defibrillation and cardiopulmonary resuscitation (CPR), directly increasing patients' chances of survival. In addition to the AED, an oxygen therapy kit, airway management equipment, and basic anti-shock supplies enable rapid and appropriate intervention in cases of sudden cardiac arrest.

The medications available in a rescue motorcycle's medical bag allow for swift intervention in life-threatening emergencies [23, 24]. For example, in anaphylactic shock, the immediate intramuscular administration of adrenaline, if administered within the first minutes, can save a patient's life [25]. In cases of epileptic seizures, the prompt use of anticonvulsants is essential to terminate the seizure and reduce the risk of neurological damage [26]. In opioid overdoses, the availability of naloxone is decisive – its early administration significantly improves prognosis [27]. Due to high mobility and shorter response times compared to ambulances, rescue motorcycles become an extremely effective tool for rapid pharmacological intervention, often determining patient survival and minimizing complications.

Time is a crucial factor in traffic accidents and other traumatic injuries [28]. In such cases, a rescue motorcycle allows for immediate action to prevent further deterioration of the victim's condition. With specialized equipment such as oxygen therapy kits, hemostatic dressings, and cervical collars, paramedics can effectively control vital functions, stabilize the patient, and reduce the risk of shock [28]. Rapid cervical spine stabilization using an orthopedic collar and hemorrhage control with hemostatic dressings prepare the patient for further transport to a medical facility, which can be decisive in life-threatening trauma cases.

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Patient transport capability

Traditional ambulances provide simultaneous medical care and safe hospital transport, which is a significant operational advantage. Emergency motorcycles lack this capability, serving only as rapid intervention tools. Thus, each motorcycle deployment requires parallel ambulance dispatch.

Research is underway to develop patient-transport motorcycles. One prototype by Yılmaz et al. [29] features a retractable seat module that can be lowered for patient loading, then raised and securely fastened behind the rider. Stability tests confirm functionality at accelerations up to 2.7 m/s^2. While still experimental, such innovations may enable motorcycle ambulances in hard-to-reach areas in the future.

Legal adaptations and further development could eventually allow motorcycle ambulances for faster patient transport in challenging environments. However, one possible limitation is the reluctance or fear of some patients – particularly elderly individuals – to be transported on a motorcycle, due to perceived discomfort, lack of perceived safety, or anxiety related to open-air transport. Therefore, even with technical feasibility, social acceptance may remain a significant barrier.

Operational costs and personnel resources

A key advantage of emergency motorcycles is their lower operational cost compared to traditional ambulances [23]. The expenses associated with EMS teams increased from PLN 1.146 billion in 2007 to PLN 3.151 billion in 2022, with funding since 2023 being directly allocated from the state budget to the National Health Fund (NFZ) [30]. According to the NFZ's final financial

plan for 2024, PLN 4.335 billion was allocated for "EMS team operational costs" [31]. These expenditures stem from equipment maintenance, personnel salaries, and the growing number of patients. The number of individuals receiving on-site medical assistance rose by 13.1% compared to 2023 [32].

Both the purchase and maintenance of ambulances represent a significant portion of NFZ expenditures. According to the Central Statistical Office (GUS), Poland currently operates 1,664 basic EMS teams and 284 specialized units [32]. A single Type B ambulance costs between PLN 500,000 and 700,000, while neonatal transport vehicles can exceed PLN 1 million [33, 34]. In contrast, an emergency motorcycle costs approximately PLN 30,000, with annual maintenance expenses of around PLN 27,000 [23].

The acquisition and upkeep of motorcycles require substantially lower financial investment, making them an attractive option not only for smaller municipalities but also for larger cities, where they can be deployed for non-critical cases that do not require a full ambulance. Their utilization can lower fuel consumption, reduce servicing costs, and the absence of a three-person crew requirement make their operation more cost-effective.

LEGAL FRAMEWORK FOR EMERGENCY MOTORCYCLES IN POLAND

Emergency motorcycles have previously been used in select Polish cities, but their deployment relied solely on internal organizational protocols of individual healthcare providers, lacking clear legal regulation [35].

Until recently, the primary legal act governing the Polish EMS system was the State Emergency Medical Services Act of September 8, 2006 [5]. This legislation did not explicitly specify the types of vehicles permitted in rescue operations, leaving room for interpretation. Generally, it was accepted that healthcare providers authorized to deliver EMS could utilize both traditional ambulances and auxiliary vehicles, provided they met safety and equipment standards.

On April 24, 2025, an amendment to the "State Emergency Medical Services Act" came into force, formally recognizing emergency motorcycles as part of the EMS system [36]. These changes codify existing operational practices. The amendment stipulates that EMS teams may use motorcycles seasonally (from May 1 to September 30) for a maximum of 12 hours per day. Additionally, they must be included in regional EMS action plans as supplementary prehospital intervention tools, with no more than one motorcycle per 400,000 inhabitants in a given voivodeship. This regulation represents a significant step toward enhancing the flexibility and efficiency of prehospital medical interventions.

Another critical legal aspect is the qualifications required for motorcycle operators. Paramedics must not only meet the formal criteria set by the EMS and "Medical Professions Act" but also hold the appropriate driving license category and a certification confirming completion of training for operating privileged vehicles [35, 37].

The introduction of standardized regulations for emergency motorcycles marks progress in unifying practices, standardizing training, and improving the safety and effectiveness of such interventions. Although the amendment only came into effect in 2025, its implementation requires ongoing analysis, monitoring, and regulatory adjustments to adapt to dynamic operational conditions and ensure optimal EMS quality.

CONCLUSIONS

In a time of rapid dynamic social, infrastructural, and technological changes, Poland's EMS system faces challenges that demand effecient and innovative solutions. One potential direction for development is the integration of emergency motorcycles as a complement to traditional EMS teams. The presented analysis indicates that while motorcycles cannot replace ambulances, they can play a significant role in prehospital care, especially in urban areas, high-traffic conditions, mass events, and time-sensitive incidents.

The comparative assessment of response times, medical equipment, operational costs, and transport capabilities demonstrates that emergency motorcycles offer distinct advantages in specific operational aspects. However, their limited cargo capacity and inability to transport patients necessitate their use as a supplementary, rather than standalone, solution.

The legal framework permitting the use of emergency motorcycles in Poland remains fragmented and may require further systematization. Despite the lack of detailed regulations, local initiatives and pilot projects have demonstrated their feasibility. Further development in this area, depends on policymakers' engagement, standardized equipment requirements, defined dispatch protocols, and integration into the medical dispatch coordination system.

Emergency motorcycles are not an alternative but a strategic enhancement to the EMS system. Their value becomes evident in scenarios where speed, accessibility, and mobility are critical. Amid rising public expectations for emergency services and an overburdened EMS system, the adoption of modern, agile, and flexible intervention methods could significantly improve prehospital care quality. Their efficiency, safety, and effectiveness however will require further research, standardization, and deliberate integration into EMS practice.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

Technological innovations in emergency medical services: the use of drones, artificial intelligence and telemedicine in crisis situations

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ABSTRACT

In the face of the growing number of crisis situations, such as natural disasters, mass casualties or pandemics, emergency medical services require increasingly effective tools enabling quick and precise response. Drones support rescue operations by quickly transporting medicines, defibrillators and blood to hard-to-reach places and enable real-time monitoring of the situation. Artificial intelligence allows for the analysis of the patient's medical data, supports clinical decision-making and optimises transport logistics and resource allocation. Telemedicine enables remote specialist consultations, sending test results and monitoring the patient's condition before reaching the medical facility. Integration of these three technologies significantly increases the effectiveness of rescue operations, shortens the response time and improves the quality of the assistance provided. The limitations and challenges related to the implementation of these solutions were also discussed, such as technical problems, lack of system standardisation, regulatory issues and ethical and legal risks, especially in the context of AI. Despite these barriers, the combination of drones, artificial intelligence and telemedicine represents a significant step towards modern, automated and better coordinated rescue operations, contributing to reducing mortality and increasing the resilience of health systems.

KEY WORDS

emergency medical services (EMS), drones, artificial intelligence (AI), telemedicine, technological innovations

INTRODUCTION

Emergency medical services play a key role in responding quickly to emergencies, natural disasters or other situations in which human life is at risk [1-4]. In the face of the growing number of incidents requiring immediate intervention, paramedics face many challenges, including quickly reaching the injured, effective remote diagnosis and effective resource management in crisis conditions [5, 6]. The development of modern technologies opens up new opportunities for emergency medical services, which can significantly improve the effectiveness and pace of providing assistance [1-3, 6]. The use of modern technologies can significantly shorten the time it takes to reach the injured, improve the accuracy of diagnosis and increase the effectiveness of the actions taken [1-5, 7-9]. Medical drones deliver defibrillators, medicines or blood to hard-to-reach places [1-3, 6, 10, 11] and thanks to artificial intelligence, paramedics can analyze patient data faster, make better decisions, and make better use of available resources, which significantly improves patient prognosis [6, 8, 12-15]. Telemedicine, in turn, enables doctors to consult with rescue teams in real time, which can be crucial for patients requiring immediate medical intervention. This will allow for faster implementation of therapy, and thus increase the patient's chances of survival [5, 6, 8, 9, 16-18].

AIM

The aim of this article is to analyze, evaluate and apply technological innovations in emergency medical services, with particular emphasis on drones, artificial intelligence (AI) and telemedicine in crisis situations. The current state of knowledge on the use of these technologies in emergency medicine will be presented, their potential benefits and challenges related to their implementation in the daily activities of paramedics will be discussed.

MATERIALS AND METHODS

To achieve the aim of this review article, the analysis of the literature will focus on studies on the role of

technological innovations, such as drones, artificial intelligence (AI) and telemedicine, in emergency medical services, with particular emphasis on their use in crisis situations. A review of available scientific publications will be conducted, including clinical trials, systematic reviews and meta-analyses, with particular emphasis on the impact of these innovations on the effectiveness and speed of rescue operations. The analysis will cover issues related to the use of drones for transporting medical equipment and monitoring the situation, the use of AI in diagnostics and medical decision support, and the role of telemedicine in remote support of rescue teams. The search for appropriate sources will be carried out using databases such as PubMed, Scopus, Web of Science and Google Scholar, which will allow for the identification of the latest and most significant publications on this topic. The next stage will be a detailed analysis of the collected materials, which will allow for the assessment of the strengths and weaknesses of previous studies and the identification of key challenges and future directions of technology development in emergency medical services.

REVIEW AND DISCUSSION

APPLICATION OF DRONES IN EMERGENCY MEDICAL SERVICES

Drones are unmanned aerial vehicles (UAVs) that are playing an increasingly important role in emergency medical services, offering quick and effective support in situations requiring immediate response from emergency services [1-3, 6, 10, 11]. Their importance has increased especially during and after the COVID-19 pandemic [1, 3, 4, 11]. Thanks to their mobility and ability to overcome difficult terrain, they can deliver medical equipment, medicines, defibrillators or blood for transfusion to hard-to-reach places, shortening the waiting time for help [1-3, 6, 10, 11]. In addition, drones equipped with cameras and sensors allow for immediate recognition of the situation at the scene, transmitting real-time data to command centers or rescue teams [1, 2, 6, 10]. The use of drones increases the efficiency of rescue operations, improves coordination of activities and minimizes the risk to rescuers, allowing them to make better-informed decisions. The dynamic development of this technology creates new opportunities in emergency medical services, contributing to saving lives and improving the quality of assistance provided [1-3, 6, 10, 11].

TYPES AND FUNCTIONS OF DRONES USED IN EMERGENCY MEDICINE

Drones used in emergency medicine can be divided into several categories depending on their function and application. Transport drones are used to quickly deliver medicines, defibrillators, blood or organs for transplantation, shortening the response time in crisis situations [1, 3, 11]. Surveillance drones: used to track health trends in populations, especially during epidemics or crisis situations [4, 11]. There are also rescue drones that can deliver first aid supplies, and those equipped with thermal imaging cameras and sensors can support the evacuation of the injured and the search for people from disaster areas [1, 6, 10]. Thanks to advanced technologies, drones play a key role in increasing the effectiveness of rescue operations and improving the chances of survival of patients [1-3, 6, 10, 11].

TECHNOLOGICAL AND REGULATORY LIMITATIONS AND CHALLENGES RELATED TO THE USE OF DRONES IN EMERGENCY MEDICAL SERVICES

The use of drones in emergency medical services has many benefits, but it is also associated with numerous technological and regulatory limitations and challenges. Key technological problems include limited flight time and range resulting from battery capacity, resistance to difficult weather conditions, and the reliability of autonomous navigation systems in a complex environment [1, 2, 11]. Another significant challenge is the integration of drones with the existing rescue system and airspace, which requires advanced unmanned aircraft traffic management systems (UTM) [1, 2]. In turn, regulatory barriers include restrictive regulations on flights beyond the operator's line of sight (BVLOS), restrictions on flights over residential areas, and the need to obtain appropriate certificates and permits [1-3, 11]. Adapting regulations to the dynamic development of technology and ensuring a high level of safety is a key challenge for the widespread implementation of drones in emergency medical services [1-3, 6]. The costs of implementing and maintaining drones and the need to employ or train appropriate operators may also be a significant limitation [6].

ARTIFICIAL INTELLIGENCE (AI) IN EMERGENCY MEDICAL SERVICES

Artificial Intelligence (AI) in emergency medical services opens up new perspectives for improving the effectiveness of interventions and optimizing medical processes. One of the key areas of AI application is real-time data analysis, which allows for the immediate interpretation of test results and monitoring of patients' vital parameters [8, 12-15, 19-21]. Machine learning algorithms can identify subtle changes in health, signaling potential threats such as cardiac arrest or stroke, even before the patient's condition deteriorates rapidly [7, 14, 19]. Thanks to this, paramedics receive valuable support in making decisions, which shortens the response time and increases the chances of effective intervention [7, 13].

AI also plays an important role in optimizing the logistics of rescue operations. Medical transport management systems using algorithms allow for determining the fastest routes to patients, taking into account current road conditions and estimated arrival times [7, 8]. In addition, solutions based on artificial intelligence support call prioritization systems by analyzing calls to

the emergency number and information from callers to properly assess the seriousness of the situation and direct the right resources to where they are most needed [7, 8]. Another groundbreaking application of AI is the use of tools for remote medical consultations in real time. Paramedics, equipped with portable devices that enable image and sound transmission, can consult with medical specialists while providing assistance [6, 8]. AI algorithms analyze images from cameras or data from portable diagnostic devices, providing initial diagnoses and recommendations. In combination with telemedicine, such solutions not only speed up the diagnostic process, but also allow for better preparation of hospitals for the admission of patients, which increases the efficiency of the entire rescue system [6, 8, 20].

RISKS AND ETHICAL ASPECTS OF USING AI

The use of artificial intelligence in emergency medical services brings not only numerous benefits, but also serious risks and ethical challenges. One of the key problems is the risk of erroneous decisions made by algorithms, which may result from imperfections in AI models or incomplete input data [7, 15]. In critical situations, relying on AI systems without proper human verification may lead to delays in providing assistance or incorrect assessment of the patient's condition [7]. In addition, there are concerns about liability for possible errors, e.g. it remains unclear who is responsible in the event that an AI decision leads to negative consequences: whether it will be software developers, users or medical institutions [15, 22]. Another important aspect is the protection of patient privacy and the security of medical data, which are necessary for training AI models. This requires the implementation of rigorous procedures for storing and processing information in order to minimize the risk of data leakage [12,20,21]. In addition, automation of emergency processes can lead to the dehumanization of medical care, weakening the patient-rescuer relationship and reducing the role of empathy and human intuition, which are crucial in crisis situations [7]. The introduction of AI in emergency medical services therefore requires not only precise legal regulations, but also constant ethical supervision to ensure that this technology supports people and does not replace them, and that its implementation primarily serves the good of patients [12, 20, 21].

TELEMEDICINE IN CRISIS SITUATIONS

Telemedicine is playing an increasingly important role in emergency medical services, especially in crisis situations, where quick access to specialist knowledge can decide about the patient's life [9, 14, 16]. It played a significant role during the COVID-19 pandemic, when contact with the patient, thanks to it, could take place remotely [9, 23, 24]. Using advanced communication technologies, rescue teams can consult with medical specialists in real time, send medical data such as test results, diagnostic images or vital signs, and receive instructions on further action [5, 9, 14, 16-18]. Furthermore, the integration of telemedicine systems with portable devices and mobile applications allows for ongoing monitoring of the patient's condition already at the pre-hospital stage, which shortens the time needed to make a diagnosis and start treatment [5, 9, 14, 16, 18]. In crisis situations, telemedicine not only increases the effectiveness of rescue operations, but also improves coordination between medical teams and facilitates decision-making, which significantly affects the quality of the assistance provided and the chances of survival of patients [9, 16, 18].

TECHNICAL AND LOGISTICAL CHALLENGES OF TELEMEDICINE IN CRISIS SITUATIONS

Despite its undeniable benefits, implementing telemedicine in crisis situations is associated with many challenges. One of the key issues is ensuring a stable and reliable internet connection, which is necessary for transmitting data in real time. In places with limited telecommunications infrastructure, such as rural areas, mountainous areas, areas affected by natural disasters or areas of armed conflict, maintaining continuous communication can be difficult [8, 9, 17, 18]. Another challenge is the interoperability of systems, as different medical facilities often use different platforms and protocols, which hinders the efficient flow of information [9, 25]. Another important aspect is the protection of patient data and ensuring an appropriate level of cybersecurity to prevent unauthorized access to sensitive medical information [9, 17, 24]. In addition, effective telemedicine requires appropriate training of medical personnel, both in the use of equipment and the interpretation of data transmitted remotely, which can be an organizational and financial challenge [16]. Like all new technologies, telemedicine also requires financial outlays, especially at the beginning of its implementation [9, 16, 24]. The development of telemedicine in emergency medical services therefore requires not only investment in modern technologies, but also the creation of consistent standards and procedures that will guarantee its effectiveness and safety in all conditions [9, 16, 18].

SYNERGY OF DRONES, AI AND TELEMEDICINE IN RESCUE OPERATIONS

The synergy of drones, artificial intelligence (AI) and telemedicine opens up new possibilities in rescue operations, significantly increasing the efficiency and speed of providing assistance in crisis situations [6, 11, 14, 26]. Drones equipped with cameras, sensors and AI systems can quickly reach hard-to-reach places, delivering medical equipment, defibrillators or medicines even before the arrival of rescue teams [1-3, 6, 10, 11, 26]. AI analyzes data collected by drones, which include: images from the scene, environmental parameters or the condition of the injured, and automatically identifies priorities for action and potential threats [6, 26]. In combination with

telemedicine, on-site rescuers can receive remote support from specialists who, based on live images, medical data and video conferences, can make key diagnostic and therapeutic decisions [6, 11, 14]. Such solutions not only shorten the response time, but also improve the coordination of actions, enabling more precise resource management and more effective life saving, especially in situations of mass events or natural disasters [6, 11, 14, 26]. The integration of these three technologies is a milestone in the development of modern medical rescue, paving the way for more automated, precise, faster and coordinated actions [6, 14, 26].

POTENTIAL BENEFITS FOR HEALTHCARE SYSTEMS AND SOCIETY

The integration of drones, artificial intelligence and telemedicine in rescue operations has enormous potential benefits for both healthcare systems and society [6, 26]. First of all, improving the process of providing assistance in crisis situations translates into reduced mortality and reduced health complications thanks to faster arrival of the necessary medical support [6, 11, 26]. Automation of many processes, such as triage or analysis of medical data, relieves the emergency and medical personnel, allowing them to focus on direct patient care [7, 14, 21, 26]. In addition, the use of modern technologies improves the allocation of resources, optimizing the time and costs of rescue operations, which is particularly important for overloaded healthcare systems [6, 7]. At the social level, greater availability of remote medical assistance increases the sense of security, especially in regions far from medical facilities or exposed to natural disasters [6, 11]. In the long term, the development of these technologies may contribute to building a more resilient and flexible healthcare system, ready to effectively respond to the challenges of global crises [6].

CONLUSIONS

Emergency medical services are evolving rapidly thanks to the use of modern technologies such as drones, artificial intelligence and telemedicine, which significantly improve the efficiency and pace of providing assistance in crisis situations. Drones play a key role in delivering medical equipment, medicines and defibrillators to hard-to-reach places, as well as in monitoring the situation thanks to built-in cameras and sensors. AI supports the analysis of patient data in real time, optimizes the logistics of rescue operations and helps make better medical decisions. Telemedicine enables remote consultations between paramedics and specialists, which shortens the time of implementing appropriate procedures and increases patients' chances of survival.

Despite numerous benefits, the implementation of these technologies is associated with challenges, such as the limited range of drones, the need for integration with existing rescue systems and regulatory issues. AI raises concerns about liability for possible errors and the protection of patient data, while telemedicine requires reliable connectivity and standardization of systems. However, the synergy of these technologies opens up new possibilities in the coordination of rescue operations, improves resource management and increases the effectiveness of interventions.

The integration of drones, AI and telemedicine in emergency medical services is a promising step towards more automated, precise and coordinated actions, contributing to saving lives, reducing mortality and optimizing resources in healthcare systems.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

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Point-of-care ultrasound for diving emergencies: A comprehensive review

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ABSTRACT

Diving-related medical emergencies can lead to life-threatening complications if not promptly diagnosed and treated. This narrative review explores the most common conditions, including decompression sickness, pneumothorax, immersion pulmonary edema, arterial and venous gas embolisms, and subcutaneous emphysema. The variability in clinical presentations and the urgency of intervention highlight the limitations of traditional diagnostic methods, particularly in out of hospital settings. Increasing attention has been drawn to the use of ultrasonographic techniques, especially point-of-care ultrasound, as a reliable and efficient tool for initial evaluation. Its portability, real-time imaging capability, and minimal infrastructure requirements make it especially suitable for diving incidents occurring far from advanced medical facilities. However, inconsistencies in diagnostic protocols and the lack of epidemiological data, particularly in countries like Poland, continue to challenge effective triage and treatment. This review advocates for greater integration of ultrasonography in diving medicine, improved training for healthcare personnel in coastal regions, and further research to standardize diagnostic approaches and enhance diver safety worldwide.

KEY WORDS

diving, barotrauma, ultrasonography, POCUS, decompression sickness

INTRODUCTION

The most common injuries associated with diving include barotrauma, decompression sickness, and panic attacks. Among these, decompression sickness (DCI) is the most frequently reported condition, although it is not common in the general sense. It affects approximately 16 out of every 100,000 divers annually [1]. Until recently, it was commonly believed that the majority of diving-related incidents and health complications were associated with commercial diving. However, according to the most recent report, out of 189 documented diving fatalities, 100 were attributed to recreational diving [2]. Such fatal outcomes are frequently linked to drowning or cardiac events during diving activities [3]. These data provide a global perspective, but the epidemiology of diving accidents in Poland remains a poorly documented area. The most recent available study covers the years 2003-2014 and is based on an analysis of 99 serious incidents involving 113 divers. These data do not originate from official records but from an internet forum, highlighting the lack of systematic, government monitoring of such incidents [4]. A decade later, there is still no national database of diving accidents in Poland, which makes it impossible to reliably assess the scale of the problem, compare it with international data, or evaluate the effectiveness of emergency response measures.

The analysis of Divers Alert Network (DAN) reports revealed that the average response time of emergency systems was 1–3 hours in the USA and Europe, while in tropical and remote areas, access to assistance exceeded 6 hours in 30% of cases [5]. This highlights the importance of timely diagnosis, which should ideally occur at the scene of the incident or during transport. In such situations, portable devices prove to be the most effective tools for rapid assessment and decision-making. Given the proximity of diving centers to medical facilities, there is a pressing need to train hospital personnel in these areas to manage diving-related emergencies effectively.

Despite the high incidence of symptoms following diving accidents, the evaluation and management of these cases remain inconsistent. The sudden onset, variability in clinical presentation, and potential for severe complications make diagnosis and treatment challenging based solely on physical examination. Among the diagnostic tools available, ultrasonography emerges as a particularly beneficial choice. It offers portability, non-invasiveness, and real-time imaging capabilities, making it well-suited for diving emergencies. Unlike radiological imaging, ultrasonography requires minimal infrastructure and enables on-site diagnosis, thus avoiding the risks associated with transferring critically ill patients. There are reports of successful use of ultrasound underwater at a depth of 42 meters for lung ultrasound, demonstrating the portability and feasibility of the device for applications in commercial diving [6]. Moreover, it is an affordable and accessible solution that requires minimal training time for medical personnel to use effectively. There is data showing that even a single-day course at

a simulation center can lead to proficient use of ultrasound with valuable diagnostic outcomes without compromising patient care [7]. Such innovations highlight the potential for expanding the role of ultrasonography in diving-related accidents. However, the lack of consensus on an ideal diagnostic approach further complicates triage and delays interventions, which are critical for preventing severe outcomes.

AIM

This narrative review aims to assess the most common diving emergencies and evaluate the effectiveness and sensitivity of various diagnostic methods, with a focus on ultrasonographic techniques.

MATERIAL AND METHODS

This narrative review was conducted to summarize and synthesize the current state of knowledge on the topic of point-of-care ultrasound for diving emergencies. We performed a comprehensive and non-systematic search of relevant literature using major electronic databases, including PubMed, Scopus, and Google Scholar. The selection of sources was guided by the relevance of the publications to the subject matter, as assessed by the authors.

The literature search was conducted between September and December 2024, and included articles published in English. Both original research articles and review papers were considered. Given the narrative nature of this review, no formal quality assessment tool was applied. Instead, the included publications were critically appraised for their contribution to the field and integrated into the review through thematic synthesis.

REVIEW AND DISCUSSION

PNEUMOTHORAX

Pneumothorax in divers is a condition caused by changes in pressure during diving. As a diver ascends, the surrounding pressure decreases, leading to the expansion of gases within the lungs. If the diver holds their breath or has an airway obstruction, the trapped air cannot escape, causing hyperinflation of the lung tissue. This can lead to alveolar rupture and the leakage of air into the pleural space, resulting in pneumothorax. Common symptoms include sudden chest pain, dyspnea, cyanosis, and pain migrating to the shoulder [8].

Various diagnostic methods are available for detecting pneumothorax, each with its own advantages and limitations. Chest X-ray has historically been the standard imaging technique, but its sensitivity is relatively low, especially for small pneumothoraces. In the study by Rowan et al., ultrasound detected 100% of pneumothorax cases, whereas chest X-ray had a sensitivity of only 36%. Additionally, ultrasound allows for diagnosis in an average of 2.3 minutes, while performing and analyzing an X-ray takes approximately 20 minutes [9]. Computed tomography (CT) is the gold standard for diagnosing pneumothorax, offering nearly 100% sensitivity; however, its use in emergency or field settings is often impractical due to logistical constraints, radiation exposure, and the time required for image acquisition [10]. Echocardiography (ECHO) can provide supplementary information, particularly in detecting cardiac displacement and assessing right ventricular function, which may be affected by tension pneumothorax [11].

Point-of-care ultrasound (POCUS), particularly lung ultrasound (LUS), has emerged as the preferred modality for rapid and accurate pneumothorax diagnosis, especially in resource-limited or emergency settings. Studies indicate that LUS has a sensitivity of up to 98.1% and a specificity of 99.2%, surpassing the diagnostic performance of chest X-ray. Several ultrasound findings, such as the absence of lung sliding, the barcode sign on M-mode, and the lung point sign, are crucial for diagnosing pneumothorax [9]. Additionally, a novel ultrasonographic technique known as the "reverse curtain sign," described by Hwang et al., enhances the diagnostic accuracy of LUS. Unlike the normal caudal-to-rostral movement of the air curtain, this phenomenon exhibits an abnormal rostral-to-caudal shift, which is exclusively observed in the presence of pneumothorax, further improving sensitivity and specificity [12].

Given its rapid bedside application, high diagnostic accuracy, and ability to be performed in diverse environments, LUS stands out as the most effective tool for pneumothorax detection in divers.

IMMERSION PULMONARY OEDEMA

Immersion Pulmonary Edema (IPE) is a condition characterized by the accumulation of fluid in the alveoli, leading to impaired gas exchange and respiratory distress. The underlying pathophysiology of IPE is driven by hydrostatic pressure, which causes a shift of blood from the periphery to the thoracic cavity and lungs. This effect is exacerbated in cold water, where peripheral vasoconstriction further increases pulmonary capillary pressure. If the capillaries exceed their capacity to retain fluid, plasma leaks into the alveoli, resulting in pulmonary edema. Risk factors include hypertension, fluid retention tendencies, and fatigue during diving. Symptoms, such as dyspnea, frothy sputum, and hypoxemia, typically occur during or shortly after a dive [13].

The rapid and accurate diagnosis of IPE is crucial in preventing severe complications. Various imaging techniques have been evaluated for their effectiveness in diagnosing pulmonary edema in divers. LUS and POCUS are emerging as preferred methods due to their speed, portability, and ability to detect pulmonary B-lines, a hallmark of interstitial edema [14]. LUS is particularly valuable in emergency settings as it allows for immediate diagnosis without the need for advanced imaging infrastructure. Studies indicate that LUS has a higher sensitivity in detecting pulmonary edema than Doppler ultrasound, which is not effective in visualizing pulmonary artifacts such as B-lines [14, 15].

ECHO, while offering a more detailed assessment of cardiac function and potential underlying causes of IPE

(e.g., patent foramen ovale or cardiac dysfunction), is less practical in emergency settings as it requires a different ultrasound probe that is not usually part of the standard equipment of an emergency medicine team, making it less accessible for field diagnosis. However, it is recommended for divers with recurrent IPE or suspected cardiac abnormalities [16].

Chest X-ray and CT scans remain useful in severe or uncertain cases, particularly when other conditions need to be ruled out. However, their limitations include radiation exposure, the need for hospital-based imaging, and lower sensitivity compared to LUS in early-stage pulmonary edema detection [17].

In conclusion, recent guidelines from the South Pacific Underwater Medicine Society and the UK Diving Medical Committee (2024) emphasize LUS as the preferred diagnostic method for IPE due to its accuracy in detecting pulmonary B-lines and its practicality in field conditions [18]. ECHO is recommended for divers at risk of recurrent IPE, while chest X-ray and CT scans are reserved for severe or ambiguous cases. Overall, LUS and POCUS offer the most effective and accessible diagnostic solutions for pulmonary edema in divers.

GAS EMBOLISMS

A gas embolism after diving results from the formation and entry of gas bubbles into the circulation. It can occur in two forms:

ARTERIAL GAS EMBOLISM

Arterial gas embolism (AGE) is a potentially life-threatening condition that occurs primarily due to pulmonary barotrauma, often as a result of rapid ascent without adequate exhalation during diving. According to Boyle's law, as ambient pressure decreases upon ascent, the volume of gas within the lungs expands. If this expansion exceeds the elastic limits of the lung tissue, alveolar rupture can occur, leading to the entry of gas bubbles into the pulmonary vasculature. Given the extensive vascularization of the lungs, these bubbles can rapidly reach the pulmonary veins and enter systemic circulation, particularly in individuals with a patent foramen ovale (PFO). Once in the arterial system, gas emboli can obstruct cerebral, coronary, or peripheral arteries, leading to ischemic events such as stroke [19], myocardial infarction [20], or kidney failure [21]. Due to the severity and rapid progression of AGE, timely and accurate diagnosis is critical for appropriate management [22].

Recent studies suggest that arterialization of venous gas emboli can occur after scuba diving even in individuals without a PFO, challenging the traditional assumption that PFO is the primary conduit for paradoxical embolization. Ljubković et al. (2012) demonstrated that gas bubbles can bypass the pulmonary filtration system through transpulmonary passage, leading to their entry into the arterial circulation [23]. This phenomenon is particularly observed in divers with a high post-dive bubble load and may be influenced by individual variations in pulmonary microcirculation and capillary permeability. The presence of arterialized bubbles, particularly in the left ventricle, poses a significant risk for ischemic complications, including neurological and cardiovascular events [19].

Various imaging and diagnostic techniques have been developed to detect AGE, each with distinct advantages and limitations. POCUS is increasingly used in emergency and critical care settings for real-time detection of intravascular gas bubbles. In a study by Aquino-Jose et. al., POCUS was found to be more sensitive than CT in detecting small amounts of intravascular gas, allowing for earlier diagnosis of AGE and timely medical intervention. The sensitivity of a normal CT is limited for directly detecting small air bubbles. Nevertheless angioCT may better assess the vasculature and identify potential gas embolism causes, such as vascular injury or iatrogenic sources[24, 25].

Another commonly utilized technique is transcranial Doppler (TCD) ultrasound, which has demonstrated effectiveness in detecting cerebral AGE by identifying microbubbles in cerebral arteries. TCD allows for real-time monitoring of embolic events and can be particularly useful in post-dive evaluations. Nonetheless, it does not provide direct visualization of emboli and may be limited in localizing specific sites of vascular obstruction [26].

In conclusion, the accurate diagnosis of AGE in divers requires a combination of imaging modalities tailored to the clinical presentation. While POCUS and Doppler ultrasound provide real-time detection of emboli at site, CT remains a good complementary hospital tool for identifying arterial gas embolism, particularly in cases involving neurological or cardiovascular complications. The integration of these techniques allows for improved diagnostic accuracy and facilitates timely intervention, ultimately reducing the risk of long-term complications associated with AGE.

VENOUS GAS EMBOLISM

Venous gas (VGE) formation following a dive is a well-documented phenomenon, primarily driven by the principles of gas solubility under pressure. According to Henry's law, increased ambient pressure during a dive causes nitrogen to dissolve in body tissues. The longer and deeper the dive, the greater the accumulation of nitrogen. Upon ascent, decreasing pressure forces nitrogen to be eliminated through the bloodstream. However, if the ascent is too rapid, nitrogen may come out of solution in the form of bubbles before it can be effectively exhaled through the lungs. In most cases, these bubbles are filtered by the pulmonary capillaries, but excessive bubble formation can overwhelm this filtration mechanism, potentially leading to pulmonary embolism, hypoxemia, and respiratory symptoms [22]. The presence of VGE is indicative of decompression stress, yet not all divers with detectable bubbles develop decompression sickness. Individual susceptibility to decompression sickness is influenced by factors such as hydration status, the

presence of a PFO, microcirculatory efficiency, and the body's ability to eliminate inert gas [27]. Various studies compare different imaging techniques, including Doppler ultrasound, 2D echocardiography, and emerging portable ultrasound devices, to evaluate their effectiveness in detecting VGE and assessing decompression stress.

In 2015, an official analysis comparing Doppler ultrasound and 2D echocardiography for bubble detection was published, evaluating different detection methods, measurement locations, and bubble assessment scales [28]. The study examined Doppler ultrasound, which quantifies bubbles through sound analysis using the Spencer and Kisman-Masurel (KM) scales, alongside 2D echocardiography, which visually assesses bubbles in the heart using the Eftedal-Brubakk (EB) scale. The findings suggested that both methods should be used whenever possible to provide a more comprehensive evaluation. The study also investigated the optimal measurement location, comparing the precordium (near the heart) with the subclavian vein. The precordium was identified as the most effective site for monitoring bubbles in large veins, whereas the subclavian vein provided additional information but was less sensitive to detecting small bubbles, as it does not account for VGE originating from the lower body circulation. Additionally, doppler ultrasound operates at a frequency of 2 MHz, while 2D echocardiography utilizes frequencies ranging from 5 to 1 MHz, which affects its ability to detect smaller bubbles [29]. The analysis also highlighted that varying body positions across different studies complicate direct result comparisons. Furthermore, 2D echocardiography, employing the EB scale, offers a more detailed assessment by visualizing VGE in the right heart chambers. Since bubbles from venous circulation accumulate in the right atrium and ventricle before being filtered by the lungs, cardiac imaging provides a more sensitive approach to VGE detection. The study found that 2D echocardiography was superior in identifying VGE compared to Doppler-based techniques, suggesting that reliance on Doppler alone may underestimate decompression stress [29]. However, automated Doppler detection systems for gas bubbles in the subclavian vein have been developed, significantly improving the accuracy of Doppler-based VGE detection and potentially replacing traditional manual assessment methods [30].

In 2001 Efdal and Brubakk suggested using a contrast-enhanced ultrasound (CEUS), which employs microbubble contrast agents to enhance visualization of small gas emboli. This technique demonstrated the highest sensitivity in detecting VGE, outperforming both 2D echocardiography and Doppler ultrasound. While CEUS provides detailed information on bubble size and distribution, it has never become widely adopted due to technical limitations, specifically the need for contrast agents, making it less practical for routine field assessments [31].

In conclusion, accurate VGE detection is crucial for assessing decompression stress and DCS risk, with different imaging modalities offering varying sensitivity and practicality. Emerging portable devices, such as POCUS and Doppler, show potential but have limitations in image quality and sensitivity. Future research should focus on refining portable imaging and automated detection to enhance accuracy and accessibility in decompression monitoring.

SUBCUTANEOUS EMPHYSEMA

Subcutaneous emphysema (SE) is characterized by the presence of air within the subcutaneous tissue and soft tissues, either formed de novo or originating from other anatomical compartments. It most commonly arises as a complication of pulmonary barotrauma, which occurs in approximately 1-5 cases per 10 000 dives. Among the complications of pulmonary barotrauma, subcutaneous emphysema is the rarest, occurring less frequently than pneumothorax or pneumomediastinum [32].

During a rapid ascent while diving, the pressure inside the alveoli can rise too quickly, causing them to rupture. This allows air to escape into the interstitial space. From there, the air can move toward the center of the chest into the pulmonary hilum and enter the mediastinum, leading to pneumomediastinum. Air in the mediastinum can then travel along blood vessels and the trachea, eventually reaching the neck and causing subcutaneous emphysema[33, 34].

The most common clinical manifestation is swelling localized around the chest, neck, and head, often accompanied by pain. Other symptoms that may occur during the course of the condition include sore throat, difficulty swallowing, neck discomfort, shortness of breath, and wheezing. In cases where deeper structures are involved, life-threatening complications such as respiratory obstruction, respiratory acidosis, and complete respiratory failure may develop. In such scenarios, immediate life-saving interventions such as intubation or tracheostomy may be necessary, so timely and accurate diagnosis of SE is essential to prevent serious complications [35].

SE is a unique clinical entity that can often be diagnosed based solely on physical examination. Traditionally, the diagnosis relies on both palpation and imaging modalities, including chest X-ray and computed tomography CT. José da Costa et al. proposed auscultating the subcutaneous swelling with a stethoscope, which may be particularly useful in settings with limited access to imaging resources [36].

To confirm the presence of SE using imaging modalities, Das et al. employed POCUS as a first-line diagnostic tool. This approach enabled rapid detection of air in the subcutaneous tissues. However, a large volume of air significantly limited the penetration of ultrasound waves, preventing assessment of deeper structures such as the pleural line. A standard chest X-ray was subsequently performed, confirming the presence of emphysema [37].

Although the literature does not explicitly define CT as the "gold standard" for diagnosing subcutaneous

emphysema, it remains the most frequently employed imaging modality in hospital settings[38].

CONCLUSIONS

Medical emergencies related to diving, including decompression sickness, pneumothorax, gas embolisms and others need quick and precise diagnosis to enhance outcomes. Ultrasonography, specifically POCUS, has been greatly beneficial because of its portability and real-time imaging. Ultrasound proves to be a very promising tool capable of providing preliminary diagnoses for a wide range of medical conditions affecting various organ systems. In comparison to conventional techniques such as X-rays and CT scans, ultrasound facilitates quicker and more available diagnosis in the emergency room. Nevertheless, the absence of standardized diagnostic criteria continues to be a limitation, emphasizing the necessity for additional research and training. As well as the lack of official data regarding epidemiology of diving incidents. The incorporation of portable ultrasound into diving medicine has the potential to greatly improve early detection and treatment, enhancing diver safety.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

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Comparison of PTSD diagnostic criteria according to ICD-10 and ICD-11: Implications for practical medicine

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ABSTRACT

The article provides a comparative analysis of post-traumatic stress disorder (PTSD) diagnostic criteria between the International Classification of Diseases, Tenth Revision and Eleventh Revision, emphasising the clinical implications of these changes. PTSD is a complex condition arising from exposure to severe trauma, characterised by symptoms of re-experiencing, avoidance, and hyperarousal. The transition from the older classification to the newest revision indicates a paradigm shift, introducing a simplified three-symptom cluster model and acknowledging complex post-traumatic stress disorder (cPTSD) as a distinct entity. cPTSD is characterised by disturbances in emotional regulation and relational functioning, and is associated with chronic interpersonal trauma. It is important to differentiate this condition from borderline personality disorder (BPD) due to the overlap in symptoms. The paper reviews diagnostic distinctions, epidemiological impacts, and implications for therapeutic strategies, highlighting how the new classification reduces diagnosis frequency by tightening criteria and facilitating more accurate identification. The study emphasises the necessity for clinicians to enhance their awareness and skills in differentiating between these disorders in order to optimise treatment planning. Furthermore, the article discusses culturally informed diagnostic considerations and presents evidence supporting the utility of standardized diagnostic tools attuned to the latest classification. The article's central argument is that the refined diagnostic framework improves the precision and effectiveness of identifying trauma-related disorders. This is vital for guiding appropriate interventions and improving patient outcomes in clinical practice. The evolving understanding of trauma-related psychopathology underscores the significance of ongoing research and adaptation in diagnostic systems.

KEY WORDS

ICD, DSM-V, post-traumatic stress disorder, personality disorders, trauma

INTRODUCTION

Post-traumatic stress disorder (PTSD) has been the focus of clinical psychology and psychiatry for years as one of the best described and most complex disorders resulting from exposure to trauma. The prevalence of PTSD varies significantly depending on the population studied, ranging from 6.9% in the general population of the United States [1] to an alarming 32% among World War II survivors in the Polish population [2].

The current geopolitical situation, including the war in Ukraine and the escalation of climate disasters, is directly linked to an increase in the number of people exposed to serious stressors and, consequently, to mental health disorders [3,4]. This has prompted the scientific community to further refine the diagnostic criteria for PTSD, which is reflected in the latest updates to the ICD-11 classification system. At the same time, in clinical practice, patients with PTSD often visit general practitioners and hospital emergency departments, which implies the need for increased diagnostic vigilance on the part of all physicians, not just psychiatrists [5].

The evolution of the diagnostic approach has led to a paradigm shift in this field, resulting in the identification of three main groups of PTSD symptoms: flashbacks, avoidance and excessive alertness, which are considered pathognomonic for the diagnosis of this nosological entity [6]. However, the emergence of a newly identified nosological entity, complex PTSD (cPTSD), has sparked controversy, mainly due to its similarities to borderline personality disorder (BPD) [6]. The key objective of this paper is to present the current state of knowledge on PTSD, cPTSD and BPD and to highlight the subtle but clinically significant differences in their differential diagnosis.

AIM

The aim of this study is to compare the diagnostic criteria for post-traumatic stress disorder between the International Classification of Diseases, 10th Revision (ICD-10) and the 11th Revision (ICD-11) and to draw attention to the distinction of a new nosological entity, cPTSD, as well as the need to differentiate it from BPD.

MATERIALS AND METHODS

This study was conducted as a structured narrative literature review with elements of a systematic approach. Its objective was to compare the diagnostic criteria for PTSD in the ICD-10 and ICD-11, and to analyse their clinical implications. The newly introduced nosological entity of cPTSD, which was not previously included in the ICD-10 classification, was also discussed.

A comprehensive literature search was conducted in the PubMed database, encompassing publications from January 1992 (the introduction of ICD-10) to June 2025 (the most recent available literature). The following search terms and Boolean operators were used: "post-traumatic stress disorder" OR "PTSD" AND "ICD-10" AND "ICD-11", supplemented with "complex PTSD", "cPTSD", "borderline personality disorder", "diagnostic criteria", and "epidemiology". Additional relevant sources were identified through a manual search of the reference lists in the retrieved articles.

The diagnostic criteria were extracted directly from official WHO publications and then compared in parallel. The comparison prioritised:

- core symptom clusters (intrusion, avoidance, hyperarousal);
- symptom definitions and thresholds;
- the presence or absence of comorbid features, such as disturbances in self-organisation in cPTSD;
- clinical implications for differential diagnosis.

The quality of the paper has been assured by independent screening and selection of the literature by the authors. Discrepancies were resolved through consensus, ensuring methodological transparency while acknowledging that this review does not constitute a full systematic review.

REVIEW

In all major classifications (ICD-10, ICD-11 and Diagnostic and Statistical Manual of Mental Disorders,

Table 1. Comparison of PTSD diagnostic criteria in ICD-10, DSM-5 and ICD-11

Criterion	ICD-10 (WHO, 1992)	DSM-5 (APA, 2013)	ICD-11 (WHO, 2018)
Structure of diagnostic criteria	Traditional definition (ICD-10 F43.1): re-experiencing, avoidance, and hyperarousal; around 13 symptoms listed	Structured into 4 clusters: A (stressor), B (intrusion), C (avoidance), D (negative alterations in cognition/mood), E (arousal/reactivity)	Simplified into 3 core groups: (1) re-experiencing in the present, (2) avoidance, (3) persistent sense of threat. cPTSD introduced separately
Duration of symptoms	Typically >1 month to qualify as PTSD (acute/chronic specifiers)	Symptoms must persist for >1 month (criteria B–E)	Symptoms must persist for 'several weeks'; less precise but implies clinically significant persistence
Intrusion symptoms	Flashbacks, nightmares, intrusive memories	≥1 intrusion symptom required (e.g., intrusive memories, nightmares, flashbacks, distress at reminders)	Re-experiencing as 'here and now' (flashbacks, nightmares)
Avoidance symptoms	Avoidance of reminders (thoughts, places, people)	≥1 avoidance symptom required (internal or external reminders)	Avoidance required (thoughts/feelings or external reminders)
Hyperarousal symptoms	Increased arousal, irritability, sleep problems	≥2 arousal/reactivity symptoms required (e.g., hypervigilance, irritability, exaggerated startle, sleep/concentration problems)	Persistent sense of threat expressed as hypervigilance and exaggerated startle
Main difference in the criteria	Broader template with many non-specific symptoms	Operationalized with 4 clusters and symptom thresholds; includes negative cognition/mood changes	Narrowed focus on 3 core clusters; excludes non-specific symptoms; distinguishes PTSD from cPTSD
Classification approach	Category: 'Reaction to severe stress and adjustment disorders'; broader and more inclusive	Category: 'Trauma and Stressor-Related Disorders'; operationalized with symptom counts and thresholds	Focused on clinical essence, simplified, cPTSD added as separate diagnosis
Clinical notes	Catches more (including milder) cases; ICD-10 still widely used internationally	More specific thresholds; includes dissociative subtype; useful in research and structured clinical practice	Identifies fewer but more severe cases; cPTSD distinction crucial; narrower definition affects prevalence and treatment access

Source: Table created by the author based on ICD-10 (WHO, 1992), ICD-11 (WHO, 2018) and DSM-5 (APA, 2013) [7-9]

5th edition – DSM-5), the starting point for diagnosing PTSD is exposure to a traumatic event that threatens life, physical or mental integrity, or health. Three essential features are shared across systems: re-experiencing (intrusions), avoidance, and heightened alertness [7-9].

DSM-5 expands the diagnostic framework for PTSD with four groups of symptoms, incorporating negative alterations in cognitions and mood (e.g., self-blame, persistent negative self-image) and allowing the identification of subtypes, such as the dissociative subtype [7]. Compared to ICD-11, the DSM-5 approach is broader and more detailed as presented in Table 1. However, it should be noted that DSM-5 is not an official diagnostic system in Poland or most European countries, and serves only as an advisory tool in psychotherapy, scientific research and medical education.

ICD-10 describes PTSD as a reaction to exceptionally stressful events and limits its criteria to core symptoms, without detailed cognitive specifications [8]. ICD-11 further simplifies the structure by focusing on three core symptom groups, with intrusions defined more precisely as "re-experiencing in the present" (e.g., flashbacks), and introduces a separate diagnostic entity – cPTSD – associated with chronic, repeated, interpersonal trauma and disturbances in emotional regulation and relational functioning [9]. Table 2 summarizes the distinguishing features between PTSD and cPTSD.

DISCUSSION

Studies have been conducted comparing the diagnosis of PTSD according to the ICD-10 and ICD-11 criteria. In a study involving several countries (including Switzerland, the USA, and Japan), the frequency of PTSD diagnosis within 60 days of a traumatic event was 24.89% for ICD-10 and 12.94% for ICD-11 in the same study groups [10]. This means that the frequency of PTSD diagnosis based on the diagnostic criteria contained in ICD-11 was twice as low [10]. The same authors also studied the frequency of PTSD diagnoses in the time interval from 122 days to 456 days. It turns out that, as before, the frequency of PTSD diagnosis according to ICD-10 was twice as high as that according to ICD-11, amounting to 14.10% for ICD-10 and 6.88% for ICD-11 [10]. In light of this analysis, it was demonstrated that the simplification and, at the same time, tightening of diagnostic criteria and the introduction of a new nosological entity – cPTSD in ICD-11 – had a significant impact on the frequency of diagnosis [10]. This also implies a change in therapeutic approaches.

In the ICD-11 classification, the criteria for diagnosing PTSD have been standardised and simplified compared to the ICD-10 classification. According to ICD-11, the diagnosis of PTSD requires the presence of symptoms in three basic dimensions: intrusion, avoidance and excessive alertness [9]. In addition, cPTSD has been dis-

Table 2. Comparison of PTSD and cPTSD in ICD-11

Criterion	PTSD in ICD-11	cPTSD in ICD-11
Structure of diagnostic criteria	Simplified into 3 core groups: (1) re-experiencing in the present, (2) avoidance, (3) persistent sense of threat. cPTSD introduced separately	Includes all PTSD criteria plus additional symptoms grouped under "Disturbances in Self-Organization" (DSO)
Duration of symptoms	Symptoms must persist for 'several weeks'; less precise but implies clinically significant persistence	Same as PTSD – symptoms must persist for 'several weeks'.
Intrusion symptoms	Re-experiencing as "here and now" (flashbacks, nightmares)	Same PTSD intrusion symptoms must be present
Avoidance symptoms	Avoidance required (thoughts/feelings or external reminders)	Same PTSD avoidance symptoms must be present
Hyperarousal symptoms	Persistent sense of threat expressed as hypervigilance and exaggerated startle	Same PTSD hyperarousal symptoms must be present
Affective dysregulation	-	Severe emotional reactivity, emotional numbing, difficulties in maintaining composure
Negative self-concept	-	Persistent beliefs of worthlessness, shame and guilt accompanied by diminished self-esteem
Disturbances in relationships	-	Difficulties in feeling close to others and in sustaining relationships
Origin of trauma	Exposure to an event or situation (either short- or long-lasting) of an extremely threatening or horrific nature	Exposure to an event or a series of events of an extremely threatening of horrific nature, most commonly prolonged or repetetive events from which escape is difficult or impossible
Therapeutic approach	Exposure-based therapies and Eye Movement Desensitization and Reprocessing (EMDR)	A phased, integrative approach involving emotional regulation, identity reconstruction and relational therapy

Source: Table created by the author based on ICD-11 (WHO, 2018) [9].

tinguished, which includes classic PTSD symptoms and persistent disturbances in self-organisation (DSO) such as chronic emotional disturbances, negative self-image and difficulties in interpersonal relationships [6,9]. This syndrome needs to be differentiated from emotionally unstable personality disorder with borderline subtype – BPD. One of the most difficult diagnostic aspects remains distinguishing chronic emotional disorders in cPTSD from persistent patterns of emptiness and emotional instability characteristic of BPD [11]. The work of Miller et al. (2021) emphasised that chronic feelings of emptiness, one of the criteria for BPD, have unique qualitative and phenomenological features that distinguish them from the emotional dysregulation typical of PTSD or cPTSD [12].

Research by Powers et al. using exploratory structural equation modelling (ESEM) confirmed that the symptoms of cPTSD and BPD form distinct, albeit partially overlapping, constructs [6]. In the ICD-11 criteria-based model, PTSD clearly focuses on the response to trauma, while BPD encompasses broader emotional dysregulation, an identity disorder not directly related to a traumatic event [6, 9, 11, 12]. It has also been pointed out that tendencies towards self-harming behaviour are significantly more common and predictable in BPD than in PTSD [13, 14].

It is important to note that diagnostic pitfalls frequently arise when chronic affective dysregulation and interpersonal instability following prolonged interpersonal trauma are attributed solely to BPD. The misclassification of cases is most likely to occur in high-risk groups (e.g., survivors of intimate partner violence), where trauma-related DSO may be mistaken for personality pathology [15]. Clinically, recurring self-harm, significant identity instability, and a pervasive fear of abandonment support a diagnosis of BPD (often comorbid with PTSD), while a persistently negative, non-fluctuating self-view and trauma-anchored re-experiencing point toward cPTSD [6, 16, 17].

The ICD-11 classification is currently being implemented in Poland. Draczyńska, Mokros et al. standardised a diagnostic tool to facilitate the diagnosis of PTSD in accordance with the latest ICD-11 guidelines, namely the International Trauma Questionnaire (ITQ) [18]. The Polish version of the questionnaire demonstrated a good factor structure, consistent with the theoretical models of ICD-11 for both PTSD and cPTSD. A study conducted with its help showed that the questionnaire accurately differentiated patients with PTSD and cPTSD, as well as individuals without such a diagnosis [18]. The empirically confirmed effectiveness of the tool adapted to Polish conditions significantly expands the diagnostic possibilities in clinical practice.

Importantly, the innovative approach presented in the ICD-11 classification and the development of tools such as ITQ normalised for specific populations allow for earlier and more accurate diagnosis of both PTSD and cPTSD, especially in high-risk populations such as people who have experienced domestic violence or chronic abuse [1]. In turn, research on cultural aspects (Hualparuca-Olivera et al., 2025) indicates that cultural differences must be taken into account in the diagnosis of PTSD, which in turn has a key impact on the need to introduce changes to clinical practice in multicultural environments [6].

From a clinical perspective, proper differentiation between PTSD, cPTSD and BPD enables:

- the use of targeted forms of therapy (e.g. exposure therapy for PTSD and dialectical behaviour therapy – DBT – for BPD),
- predicting difficulties in the course of treatment (including a higher risk of self-harm in BPD compared to PTSD) [13, 14],
- improving treatment prognosis by planning interventions in line with a precise diagnosis.

LIMITATIONS

The present study is predicated on a narrative literature review, with no original quantitative analysis performed. The findings and conclusions of this study are predicated on the quality and scope of the cited studies and diagnostic manuals. No meta-analysis was conducted. It is important to note that future revisions of diagnostic classifications may result in alterations to the presented framework and interpretations. The findings must be considered in the context of the current state of the literature and the ICD-11 guidelines.

CONCLUSIONS

The introduction of new diagnostic criteria for PTSD in ICD-11 has significantly changed the approach to identifying post-traumatic mental disorders, emphasising more precise and specific recognition of the core symptoms of trauma. By simplifying the diagnostic structure into three key symptom clusters and distinguishing cPTSD as a separate nosological entity, the ICD-11 allows for more accurate differentiation between classic PTSD and complex personality disorders caused by chronic trauma.

Based on the available evidence, the new approach of ICD-11 not only improves the effectiveness of the diagnostic process but also requires clinicians to have a deeper understanding of symptom structure and advanced diagnostic skills. Correct differential diagnosis of PTSD, cPTSD and BPD remains crucial for selecting appropriate and effective forms of treatment and improving patient prognosis.

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CONFLICT OF INTEREST

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CASE STUDY

Diagnostic and therapeutic difficulties encountered by paramedics while providing pre-hospital medical assistance to a severely burned patient – a case study

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ABSTRACT

Aim: Analysis of the management of a patient with severe inhalation burns in the light of powers of a paramedic in Poland and current guidelines may enable to improve the quality of medical assistance provided by Emergency Medical Teams.

Materials and methods: We analyzed management provided by the basic emergency medical team in a patient with a thermal burn in compliance with current recommendations and the powers of paramedics in Poland. The patient was found to have a 2nd/3rd degree burn covering approximately 50% of the total body surface area and a respiratory failure which was probably caused by inhalation burns. Due to the lesions, the paramedic made the following interventions: he cleared the airway with an oropharyngeal tube, started assisted ventilation, established intravenous access to a peripheral vein on the foot, administered 500ml of 0.9% NaCl and medical oxygen, cooled the burned area and assessed body temperature. The medical records lacked information on blood pressure values, saturation, blood glucose levels and administration of analgesics.

Conclusions: 1. It may be difficult to ensure airway patency, intravenous access and monitor peripheral circulation in patients with deep burns of the face, neck and upper extremities. 2. It is necessary to improve skills of medical staff regarding the complex care of severely burned patients, particularly monitoring of vital signs and conicopuncture, establishing intraosseous access and pain management.

KEY WORDS

emergency medical team, difficulties, severe burn

INTRODUCTION

Burns are not uncommon injuries and they account for the fourth cause of hospitalization, after traffic accidents, falls and physical violence. The incidence of burns varies around the world. In 2020, 371,000 people were hospitalized due to burns in the US, and 359,000 people were treated in emergency rooms [1-4]. In Poland, it is estimated that between 300,000 and 400,000 people are treated for burns annually. Of this number, 50-70% are children [5,6]. Despite progress that has been made in medical science, providing assistance to victims with burns is still a challenge for all members of a medical team at every stage of treatment. Difficulties in providing pre-hospital medical assistance to a person with a burn may be associated with the severity of the burn and limited experience of emergency medical teams (EMTs). In addition, the age of the patient is also crucial, mainly due to the patient's health status before sustaining the burn. ABA (American Burn Association) guidelines provide that the following are considered severe burns in adults:

- superficial (i.e. 1st degree) and intermediate thickness skin burns (e.g. 2nd degree), involving more than 25% of the Total Body Surface Area (TBSA);
- full thickness skin burn (3rd/4th degree), involving more than 10% of TBSA;
- burns involving the shock area (eyes, ears, neck, hands, palms, feet, perineum);
- burns concurrent with severe injuries or conditions complicating treatment;
- electrical, chemical and inhalation burns [7].

Inhalation burns are particularly severe burns because of the risk of airway obstruction. They result from inhaling hot air, steam or chemicals. Inhalation burns should always be suspected in patients with burns of the head and neck, mouth, throat, and those who report difficulty swallowing and demonstrate clinical signs of respiratory failure [7, 8].

Airway obstruction can occur as early as 30 minutes after an inhalation burn. Hence, one of priorities of EMT management of airway obstruction at the scene is to provide early airway patency with an endotracheal tube or conicopuncture [9, 10]. Because of the risk of burn shock, Systemic Inflammatory Response Syndrome (SIRS) and Multiple Organ Dysfunction Syndrome (MODS), it is very important to properly manage patients with burns involving more than 20% of TBSA.

Limited experience and competences of medical staff in providing medical assistance to patients with respiratory distress symptoms and in performing certain medical procedures may prevent the performance of rescue operations [11-13].

AIM

Analysis of the management of a patient with severe inhalation burns in the light of powers of paramedics in Poland and current guidelines may enable to improve the quality of medical assistance provided by EMTs.

MATERIALS AND METHODS

We analyzed the management provided by paramedics in a patient with burns in compliance with recorded medical procedures and current recommendations and powers of paramedics as defined in the Regulation of the Minister of Health as of 22 June, 2023 on medical emergency activities and health services other than medical emergency activities that can be provided by a paramedic.

CASE REPORT

The primary EMT was dispatched to a wooden house fire. After about 40 minutes of firefighting, firefighters evacuated an unconscious person with multiple burns.

The paramedics proceeded to assess the patient's condition and determined that the victim was a woman, about 70 years of age, with body weight about 70 kg. Based on the assessment of basic vitals, the following were noted:

- A (Airway – assessment of oral contents and airway patency) – a threatening airway obstruction due to a circular burn on the head, swelling of the lips and tongue, which suggested a burned airway. The airway was cleared with an oropharyngeal (OP) tube No. 4;
- B (Breathing – respiratory system assessment) – the victim's breathing was shallow and slow (i.e. 8/min). Chest mobility due to the burn was limited. Weakened vesicular breathing was heard over the lung fields on both sides. Passive oxygen therapy (oxygen flow 25 l/min.) was started, followed by respiratory support with a resuscitator (respiratory rate 10/min.). No information on saturation (SpO_2) was available;
- C (Circulation – assessment of the circulatory system) – pulse on the carotid artery was present. Auscultatorily, heart tones were clear and loud. ECG picture showed a steady sinus rhythm of 100/min. An intravenous (IV) route was established on the foot (24G cannula). Deep burns on the upper extremities made it difficult to assess blood pressure (BP), pulse on radial arteries and capillary refill time (CRT);
- D (Disability – neurological and blood glucose assessment) – the patient was unconscious, Glasgow Coma Score (GCS) – 3 points. Pupils were symmetrical, wide, and they did not respond to light. There was no information on the serum glucose level;
- E (Exposure) – diagnosed severe 2nd/3rd degree thermal burn involving approximately 50% of TBSA, including circular burns of the head, neck, upper extremities, and chest and abdominal burns with concurrent inhalation burns. Non – stick clothing was removed from the patient's body. Body temperature was assessed at the ear drum membrane (37°C). The burns on the head and upper extremities were cooled with a sterile compress with 0.9% NaCl solution;
- F (Fluid Resuscitation) – 500 ml of 0.9% NaCl IV solution was infused. Due to the patient's severe general condition, inability to effectively ventilate her lungs and suspected inhalation burns, an AR (Air Rescue) helicopter was called. An AR doctor intubated the victim by videolaryngoscopy (endotracheal tube ID 7.5 mm), established an intraosseous (IO) route, and performed a chest fasciotomy. Besides, he administered Chlorsuccillin and Fentanyl and ordered to continue replacement ventilation with a resuscitator. The patient was transported by AR helicopter to a burn center. Despite the implemented management, the patient died on day 1 of hospital treatment.

DISCUSSION

Providing assistance to people with extensive, severe burns, complicated by airway burns and respiratory failure is a clinical challenge for EMTs. Besides, this assistance might be even more challenging due to limited experience and qualifications. Swelling of the mouth makes it difficult to provide airway patency with a OP tube or with application of supraglottic methods, which are ineffective in subglottic airway burns.

Circular neck burns contribute to difficulty in performing external jugular vein cannulation and also conicopuncture, which is worrying, because these are performed when other techniques supposed to ensure airway patency fail. Besides, deep and circular burns of the upper extremities can make it impossible to assess BP, peripheral perfusion, draw blood for glucose assessment and establish IV access. In addition, it is debatable whether we should perform invasive procedures at the site of deep burns or to relieve pain with opioid agents in a person demonstrating symptoms of respiratory failure, chest rigidity and unknown BP. Authorization of paramedics to perform endotracheal intubation, which is conducted only in cases of sudden cardiac arrest (SCA) as well as lack of experience in performing conicopuncture and providing assistance to patients with inhalation burns might be additional problems [11, 12].

In the presented case, a deep circular burn of the head, neck and upper extremities, as well as burns of the mouth, chest and abdominal cavity were correctly diagnosed, and inhalation burns and respiratory failure were rightly suspected. The airway was cleared with a OP tube. Initiated passive oxygen therapy and assisted ventilation with active oxygen therapy did not make the patient's respiration more efficient. However, the EMTs did

not perform endotracheal intubation/conicopuncture, as recommended in such a case, and did not clear the airway with a laryngeal mask/tube; instead, they called for assistance provided by an AR team, who always have a doctor on duty. Also in that case, the doctor on duty performed an endotracheal intubation. The reason why paramedics resign from performing the conicopuncture procedure may be related to difficulty in locating the laryngeal cricothyroid ligament in a person with a neck burn, in performing the procedure, and lack of experience. Furthermore, swelling of the mouth, tongue and throat might prevent paramedics from using a laryngeal mask/tube. This hypothesis is supported in reports of other authors, who observed that medical staff of emergency services demonstrate little interest in performing conicopuncture/ conicopunctures were performed on human cadavers, also on patients with neck burns localized on the laryngeal cricothyroid ligament [11-17]. Kulak et al conducted a survey on a group of 99 paramedics, 17 emergency nurses and 14 emergency physicians. The authors revealed that 66% of the respondents had never performed conicopuncture.

One in five respondents had not been trained to perform this procedure, and only 16% of the respondents had observed the conicopuncture procedure [12]. The above study indicates a lack of training and a need to improve the skills of performing conicopuncture in medical and nursing personnel and emergency medical students.

In the case presented in this study, the EMT established IV access on the patient's foot with a 24G infant cannula. Undoubtedly, the decision of the paramedic to establish IV access and administer infusion of 500 ml of 0.9% NaCl solution should be considered positive. However, the diameter of the applied cannula is questionable. The risk of shock increases in patients with burns involving over 15% of TBSA. Hence, it is recommended to provide IV access with two 18G cannulas and fluid resuscitation. If IV access is not possible or two attempts at the access have been unsuccessful, intraosseous access is recommended [7,9,18]. The choice of insertion site and cannula diameter may depend on the location of deep burns. Their localization on the neck, forearms and hands, makes it difficult to assess BP and determine serum glucose levels and SpO_2. It is worth pointing out that in patients with extensive burns, IV access can be established at the burn site, and the use of a larger cannula allows for maximum gravity flow of 19 ml/min. (i.e. approximately 1,140 ml/h) [7,19].

Knowledge of the Parkland formula (4 ml x kg b.w. x % TBSA) can be helpful while determining the adequate volume of transfusion fluid and reducing the risk of overhydration and swelling. A patient with body weight about 70 kg is due to undergo a transfusion of 7000 ml of fluid (4 ml x 70 kg b.w. x 50% TBSA = 14,000 ml/2) in the first 8 hours after injury, including 875 ml in the first hour (7000 ml/8 hours) [7, 9]. According to medical records, the patient received 500 ml of 0.9% NaCl.

Every burn is painful and the pain should be relieved. In the analyzed case, acute pain was reported to be relieved only with a moist compress, which was against current recommendations [7, 9, 20]. An analgesic was administered to the patient only by the AR physician. According to requirements of the National Health Fund (NHF), dispatchers have to provide EMTs with medications necessary to provide emergency medical care, including one analgesic [11, 21]. The EMT had 6 analgesics of 7 which the paramedic was authorized to administer, as well as coanalgesics and benzodia epines. In the hyperdynamic phase

of burn injury, it is recommended to treat pain with morphine or fentanyl given IV or via the IO route as well as cool, elevate and immobilize the burned limb [7, 20, 22].

The decision against administration of analgesics, including opioids and other analgesics which paramedics are authorized to administer, i.e. paracetamol, ketoprofen, methamizole, morphine, fentanyl or coanalgesics (lidocaine) – may have resulted from the inability to assess pain intensity and BP and the fear of hypotension, increased chest rigidity and respiratory failure. Oligoanalgesia may also have resulted from a lack of experience in performing analgesia in critically ill patients or the misconception that unconscious patients do not feel pain [23-25].

Routine assessment of basic vital signs in a person with a burn includes assessment of BP and SpO_2, and such were not recorded in the presented case. Examination of these parameters on a limb with a deep burn may not be possible due to edema, reduced skin turgor, intrafascial tightness syndrome, distal hypoperfusion and shock. In such cases, BP can be assessed on the burned arm. However, the burn wound must be first protected from contamination with a sterile dressing and the blood pressure cuff has to be disinfected in compliance with principles of aseptics and antisepsis.

If peripheral perfusion and BP cannot be assessed, hourly diuresis is used to evaluate the effectiveness of fluid resuscitation [9]. The fact that paramedics are allowed to catheterize the urinary bladder only under the supervision of a physician is an obstacle to monitoring hourly diuresis [11]. It can be difficult to assess saturation on affected fingers of the hand or auricle, so it is worth considering monitoring SpO_2 on the toes [9].

In the analyzed case, administration of agents to reduce the risk of obstruction and airway pressure as well as administration of bronchodilators were not reported. The paramedic was authorized to self-administer salbutamol, epinephrine and low-molecular-weight heparin. 10,000 units of inhaled low-molecular-weight heparin are recommended for patients with inhalation burns to reduce fibrin formation, fibrosis and airway obstruction [25, 26].

It is important that a severely burned patient be placed in a proper body position. In the described case, the patient lay in the "supine" position. In hemodynami-

cally stable patients with burns of the head, neck and chest, the anti-Trendelenburg position, i.e. with the torso elevated at an angle of 30-45° is advisable as such position slows the rate of edema accumulation. Elevation of burned extremities is recommended for the same purpose [7, 9, 27-29].

The extent and depth of the burn, the patient's age, lack of information regarding her condition and all of the above-mentioned factors undoubtedly made the treatment ineffective and led to death. Improving knowledge and skills of EMT staff in rarely performed medical procedures is crucial for early optimization of rescue management in people with severe burns. This can be achieved by participation in burn management courses, e.g. Emergency Management of Severe Burns (EMSB) or others, being part of postgraduate education [30].

In Poland, as in other countries, a paramedic is required to participate in, among other things, CECP (continuing education course for paramedics) every 5 years. The organizer of the CECP is obliged to provide, among other things, a conicopuncture kit and an adult manikin to perform this procedure. It is important that the post-graduate training be regularly organized for all medical professionals authorized to provide medical care in EMTs [31-33]. Due to shortage of physicians, very few specialized EMTs have this medical professional. Thus, teaching skills to primary EMT staff is highly important. In 2022, in Poland, 321 EMTs out of 1592 had a specialized status, i.e. there was a physician in the team [34, 35].

The knowledge and skills of the EMT staff need continuous improvement, especially in the area of rare medical procedures, regardless of the frequency of emergency medical care given to people with severe burns, complicated by thermal inhalation injury.

CONCLUSIONS

1. It may be difficult to ensure airway patency, intravenous access and monitor peripheral circulation in patients with deep burns of the face, neck and upper extremities.
2. Skills of medical staff in the complex care of severely burned patients should improve, especially in the areas of monitoring of vital signs and conicopuncture. Skilled staff will be able to establish intraosseous access and manage pain.

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