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RATOWNICTWO MEDYCZNE

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ORIGINAL ARTICLE

Level of quality of life and illness acceptance among patients suffering from the sick sinus syndrome (SSS) qualified for artificial cardiac pacemaker implantation

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ABSTRACT

Aim: To evaluate the level of the quality of life and illness acceptance, in relation to applicable demographic data, among people suffering from the sick sinus syndrome (SSS) and qualified for artificial cardiac pacemaker implantation.

Material and Methods: The study was conducted on 211 individuals over 65 years of age suffering from the sick sinus syndrome. 133 females and 78 males were selected from the patients of the Arrhythmia and Interventional Cardiology Clinic of the University Hospital no. 2 of the Medical University of Łódź.

Results: The average age of the patients surveyed was 78 ± 7.56 years. F The cohort included predominantly widowed or married patients with secondary or vocational educationThe determined quality of life for both genders was on a fairly similar level, i.e. $p = 0.332$. The quality of life assessment provided by patients with elementary education level was the lowest, i.e. $p < 0.001$. The level of illness acceptance among married respondents was higher in comparison to single respondents, i.e. $p<0.001$.

Conclusions: The factors contributing to the fact that patients suffering from cardiology conditions assess their quality of life on a lower level than other patients include age, not having a spouse and lower education level. The disease acceptance was best rated by younger people, those declaring to be married. The illness acceptance level (AIS scale) exerts statistically significant impact on the quality of life of the study group of patients qualified for artificial cardiac pacemaker implantation during the COVID-19 pandemic period.

KEY WORDS

quality of life, illness acceptance, sick sinus syndrome

INTRODUCTION

Modern medicine aims at improving the quality of life of people suffering from certain medical conditions. Nowadays, the mortality rate resulting from acute illnesses has decreased while the incidence of chronic diseases has increased. Therefore a serious dilemma is to be resolved, as to whether the main objective of medicine is to save a patient and keep them alive, or whether it is also important to ensure a quality of life that allows the patient to live out their life in comfort [1]. The currently referred to term of the "quality of life" was defined by Angus Campbell in 1970s. In his studies, he proved the existence of a relationship between the objective life conditions and satisfaction with life. According to Campbell, satisfaction is influenced by life experience, and not just by living condition improvement [2]. Over the years, both in clinical research and in everyday practice, the quality of life has been increasingly assessed in addition to the biological evaluation of a patient's condition, as it depends on the impact of the illness and treatment course exerted on the patient's mental, physical and social life [3]. The World Health Organisation (WHO) defines the quality of life (QofL) as an individual's perception of their position in life in the context of the culture and value systems in which they live [4]. Self-rated health is one of the factors determining the quality of life. As the number of risk factors increases, the quality of life deteriorates significantly, with such contributing factors as deteriorated well-being, feelings of sadness and anxiety, and listlessness. Negative emotional states exert impact on the quality of life of patients suffering from cardiovascular diseases [5]. Patients adopt various attitudes towards the illness which affects their overall functioning, as well as their physical and mental condition. An illness frequently forces them to alter their current way of life, and can be perceived as a challenge to overcome, loss or relief [6]. Illness acceptance mitigates negative reactions and illness-related emotions, however, patients unable to accept it experience considerable discomfort and deterioration of their adaptation capability [7]. During the COVID-19 pandemic, the population's health status was not improved, despite the decrease in the number of patients in clinics and hospitals. The lower hospitalisation rate resulted from patients' fear of being infected with the SARS-CoV-2 coronavirus. The research to date provides an assessment of the quality of life of patients before the COVID-19 pandemic. Nevertheless, there

is little data available regarding the senior citizens' quality of life during the pandemic, which makes the analysis of the quality of life of a group of respondents qualified for artificial cardiac pacemaker implantation relevant [3].

AIM

The aim of the study is to evaluate the level of the quality of life and illness acceptance, in relation to applicable demographic data, among people suffering from the sick sinus syndrome (SSS) and qualified for artificial cardiac pacemaker implantation.

MATERIAL AND METHODS

The study was conducted on 211 individuals over 65 years of age suffering from the sick sinus syndrome (SSS) and qualified for artificial cardiac pacemaker implantation. 133 females and 78 males were selected from the patients of the Arrhythmia and Interventional Cardiology Clinic of the University Hospital no. 2 and the Electrocardiography Clinic of the Central University Hospital of the Medical University of Łódź. The study was conducted during the COVID-19 pandemic, i.e. in the period from December 2020 to December 2022. The respondents qualified for artificial cardiac pacemaker implantation were divided into three age groups: from 65 to 74 years of age, from 75 to 84 years of age, and 85+ years of age. The study participation criteria included qualification for artificial cardiac pacemaker implantation, over 65 years of age, fluent verbal communication and consent to participate in the study.

The research tools included the WHOQOL-AGE quality of life assessment questionnaire, Acceptance of Illness Scale (AIS) and the author's own survey. The WHOQOL-AGE questionnaire it a tool designed to assess the quality of life of people older than 60 years of age. It contains 13 questions divided into two subscales: P1-P8, P9-P13 and P1. The questionnaire provides results of the quality of life assessment within the range from 0 to 100 [8]. The Acceptance of Illness Scale (AIS) can be applied to adults in order to assess the degree of illness acceptance in relation to each illness entity. The AIS consists of eight statements that describe the negative consequences of poor health condition. Responses to each questions are evaluated within the 5-level Likert scale, in which the score of 1 demonstrates lack of illness acceptance, and 5 indicates proper adjustment to the illness. A patient may score a maximum of 40 points. On the basis of the study results, a patient is classified for one of the three categories, i.e.: lack of illness condition acceptance – below 19 points, moderate illness condition acceptance – from 19 to 29 points, and illness condition acceptance – 30 points and above [9]. The author's own survey consisted of seven questions on social-demographic data, i.e. age, gender, height, weight, marital status, education and place of residence.

STATISTICAL ANALYSIS

The data collected by means of surveys was used to create a database to be analysed using the Statistica (StatSoft, TIBCO, Poland) software, version 13.3. Nominal variables were presented using sizes and percentages. The continuous variables within independent pairs were compared using the non-parametric Mann-Whitney U Test, and the continuous variables within numerous independent groups were compared using the non-parametric Kruskall-Wallis Test. The statistically significant results were presented using a box plot. In all cases analysed, the relevance level of $p < 0.05$ was assumed.

RESULTS

The average age of the patients surveyed was 78 ± 7.56 years. Females constituted the majority of the respondents. The cohort included predominantly widowed or married patients with secondary or vocational education, and residing in urban areas. Due to the fact that only a small number of divorced patients (2.4%) or patients declaring themselves as maidens/bachelors (3.3%) participated in the study, it was decided that these groups would be combined with the widowed participants into one group for the purposes of a further statistical analysis, i.e. the "single person" group was created. The respondents surveyed most often rated their quality of life as neither poor nor good or as good. Simultaneously, the majority of patients felt that they were satisfied with their health condition and with how their senses functioned. The surveyed patients' responses to the individual questions included in the WHOQOL-AGE questionnaire showed that they were satisfied with their personal relationships and the way they take advantage of their personal time. Simultaneously, the cohort indicated mostly moderate levels of having the energy needed for living their daily lives. While assessing their satisfaction with themselves and with the conditions in their place of residence, the patients were most often unable to clearly indicate an answer. The majority of respondents were able to control their activities and declared being satisfied with the feeling of close friendships. The majority of respondents had enough money to meet their needs. In the cohort surveyed, the majority of patients were satisfied with their ability to conduct daily activities or were unable to specify their opinion on this, while expressing moderate satisfaction with their ability to continue to achieve their goals. While assessing their illness acceptance (as per AIS), the respondents gave the highest scores to the acceptance of the illness by their families who did not treat them as a burden.

The majority of the patients in the group surveyed did not find it difficult to adapt to all limitations resulting from their condition. The respondents recognised that their illness did not prevent them from being fully adequate human beings. While assessing the surveyed respondents' acceptance of their illness, it was demonstrated that the condition does not restrict them from pursuing their favourite activities and does not make them feel unwanted or dependent on others. While assessing the average illness acceptance level among the respondents, their indirect illness acceptance (28 points)

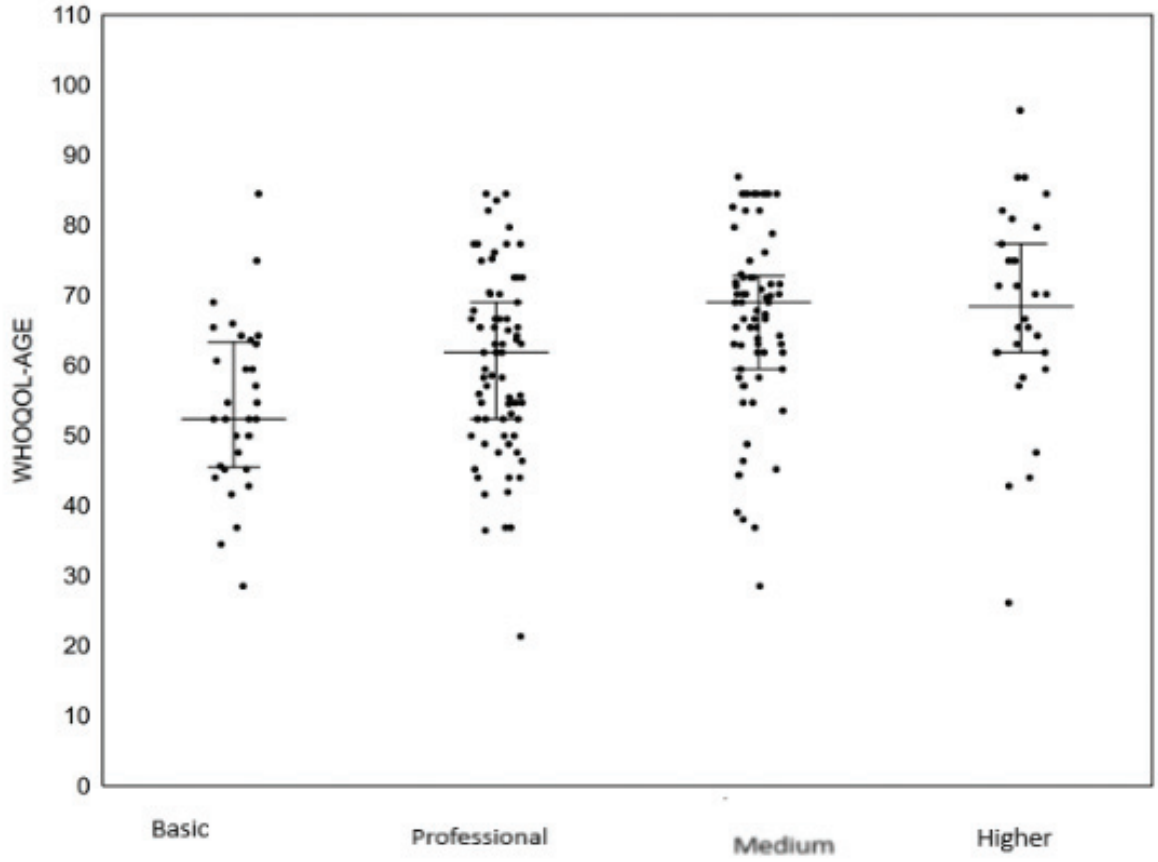

Fig. 1. Relationship according to WHOQOL-AGE and education of respondents

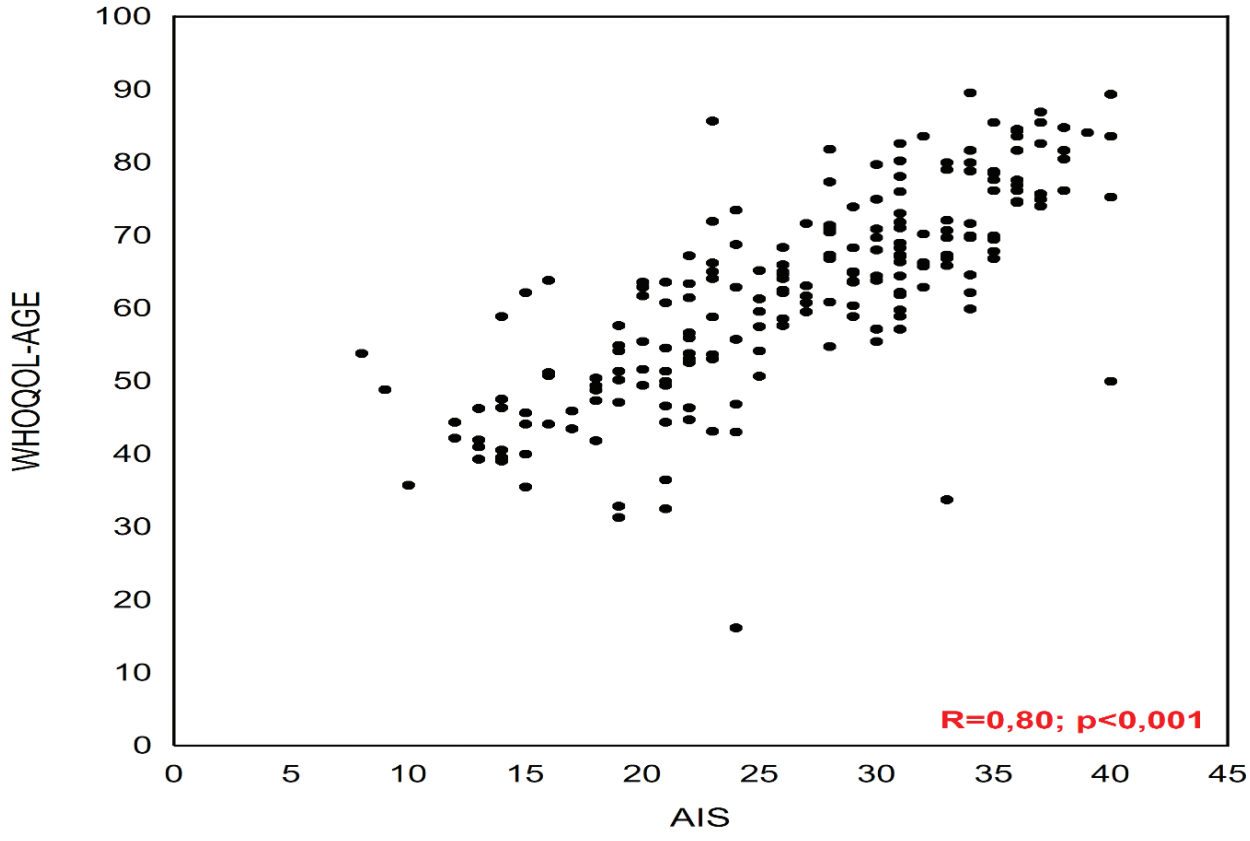

Fig. 2. The relationship between quality of life according to WHOQOL-AGE and acceptance of illness according to the AIS scale

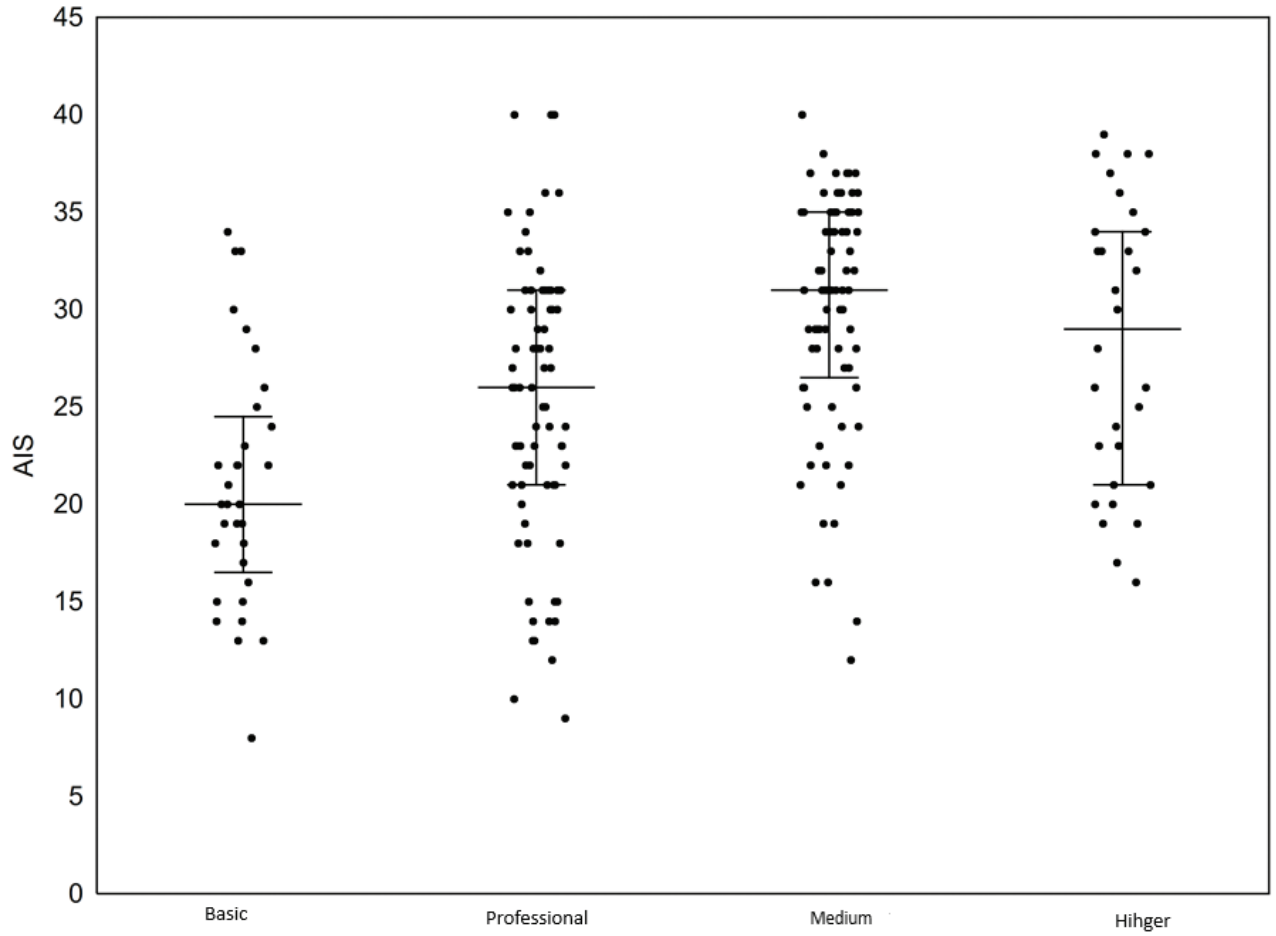

Fig. 3. Value according to the AIS scale and respondents' education

was demonstrated. While assessing the quality of life in relation to the respondents' age, it was demonstrated that older people's score obtained on the basis of the WHOQOL-AGE questionnaire was lower in comparison with younger respondents ($p < 0.001$). The survey showed that patients included in the 65-74 years of age and 75-84 years of age brackets assessed their quality of life as higher (as per the WHOGOL-AGE questionnaire) than the patients older than 85 years of age ($p = 0.002$; $p = 0.007$). In the study group of respondents, the level of quality of life for both genders was assessed at a similar level. People living in urban and rural areas rated their quality of life similarly. The analysis results demonstrated that the patients with elementary education rated their quality of life worse (as per the WHOQOL-AGE questionnaire) than patients with higher ($p < 0.001$) and secondary education ($p < 0.001$) (Fig. 1). Married patients declared a higher level of quality of life (as per the WHOQOL-AGE questionnaire) than single patients ($p < 0.001$). The analyses results showed that better illness acceptance (AIS) resulted in a higher level of the quality of life (as per the WHOQOL-AGE questionnaire), i.e. $p < 0.001$ (Fig. 2). While analysing the results obtained, it was demonstrated that older patients' score regarding their illness acceptance within the AIS scale was lower than for younger patients ($p < 0.001$). While assessing the illness acceptance within the AIS scale, it was demonstrated that both patients in the 65-74 years of age bracket and patients in the 75-84 years of age brackets showed a higher level of illness acceptance than the patients belonging to the 85+ years of age group ($p < 0.001$). The data analysis showed that both females and males declared similar levels of their illness acceptance. In the study conducted, illness acceptance at a similar level was declared by both urban and rural area residents. In the cohort surveyed, patients with elementary education demonstrated a statistically significantly worse score on the AIS scale than patients with higher ($p = 0.001$), vocational ($p = 0.048$) and secondary education ($p < 0.001$). However, the score of the patients with vocational education was significantly statistically lower in relation to AIS than for patients with secondary education, i.e. $p = 0.001$ (Fig. 3). Married respondents declared a higher level of illness acceptance in relation to AIS than "single" patients ($p < 0.001$).

DISCUSSION

The quality of life is a parameter frequently studied in the modern medicine [10]. Adulthood is a time when satisfaction with life remains at a constant level. The decrease, however, can be observed in line with population ageing [11]. Health-related problems, physical and intellectual condition deterioration and certain life events

are just some of the factors that affect the quality of life assessment [12]. In the course of the study conducted which included individuals older than 65 years of age, 37.91% of the respondents (80 individuals) assessed their quality of life as neither poor nor good. An approximately the same number of respondents declared that their quality of life is good (36.49% – 77 individuals). Only 4.74% of the respondents (10 individuals) declared that their quality of life is very poor, and 4,27% (9 individuals) of the respondents assessed it as very good. In the course of the study conducted among Polish and Croatian senior citizens, Knurowski et al. demonstrated that age influenced the population's health condition deterioration, particularly among females [13]. In the course of the study conducted among the older population of Tibet, the Polish Academy of Sciences (PAN) demonstrated that health condition deterioration was age-related [14]. The author's own study confirms the above-mentioned findings, i.e. it demonstrates that the respondents' quality of life depends on their age. In the group of senior citizens surveyed, the highest quality of life was declared by the youngest patients (60-74 years of age, 65.48 points). The lowest quality of life was declared by the patients older than 85 years of age (54.72 points). Trafiałek specified the quality of life as the new lifestyle for the retired [15]. In their study, Onunkwor et al. determined that the quality of life was influenced by factors such as gender, age, education level, coexisting illnesses and housing conditions [16]. In the course of this study, both males and females assessed their quality of life on a similar level. In the course of the study conducted on the Brazilian population, Teston et al. demonstrated that the quality of life predominantly depends on housing conditions [17]. However, Xavier et al. demonstrated that Brazilian senior citizens' involvement in household chores or gardening and similar rural activities exerted positive impact on their quality of life perception [18]. In the course of the ongoing study, nearly half of respondents were unable to say how satisfied they were with their place of residence. 1/3 of the senior citizens stated that their everyday life conditions are satisfactory, and only two individuals declared that they were highly satisfied with their place of residence. Polish senior citizens declared that they are fairly satisfied with their ability to perform everyday activities (45.02% – 95 individuals) or were unable to rate their level of satisfaction (42.65% – 90 individuals). Similarly to other parameters related to the quality of life, 4 individuals were very satisfied or very dissatisfied with their own ability to function on a daily basis. According to Knurowski, the quality of life and satisfaction with it were significantly affected by senior citizens' education level [13]. Sherizadeh et al. demonstrated that education was the factor exerting positive impact on the quality of life assessment results [16]. The ongoing study showed that the respondents' level of education affected the quality of life assessment results. In the cohort surveyed, patients with secondary education rated their quality of life better than those with higher education. However, patients with primary education rated their quality of life as the worst among all individuals surveyed. The study conducted by Zhou et al. showed that the social-economic status was an element affecting human health and therefore influencing the quality of life of the elderly [19]. Studies conducted within the Chinese population showed that low social-economic status and low level of the quality of life assessment resulted in sarcopenia occurrences among the residents [20]. The results of the ongoing study showed that almost a half of the respondents (47.39% – 100 individuals) declared that they have enough money to fulfil their personal needs. 43.6% (92 individuals) stated that they had a moderate sum of money, and 1.42% (3 individuals) stated that they had no financial means whatsoever. The available literature shows that the health condition is a factor largely affecting the respondents' quality of life assessments. Moreover, the relationship between the sensory fitness and quality of life was demonstrated [21]. Previous studies showed that 1/3 of Polish citizens declared occurrences of chronic illnesses lasting for at least 6 months. 84% of individuals older than 70 years of age experienced long-term health issues [22]. According to the Central Statistical Office, 20% of the elderly assessed their health condition as good/very good, 1/2 of them assessed their health condition as average, and 1/3 of senior citizens declared that their health condition is poor / very poor [23]. The author's own studies demonstrated that almost 2/3 of the respondents (61.14% – 129 individuals) assessed their sensory fitness are satisfactory. 21.33% (45 individuals) were unable to determine whether they are satisfied, or not, with their sensory fitness. However, 1.42% (3 individuals) claimed that they are highly dissatisfied with the way their senses function. The current study showed that 61.14% (129 individuals) of the respondents belonging to the group diagnosed were satisfied with their health condition, and 23.22% (49 individuals) were unable to determine their health condition. This group included 4 individuals demonstrating at least dissatisfaction with their health condition. Previous studies showed that social relationships affected the elderly people's assessment of their quality of life. In the course of the study conducted among Malaysian senior citizens, Khan et al. demonstrated that respondents living with their family or friends declared a higher level of the quality of life [24]. In the course of the current study, it was determined that almost 50% of the respondents declared that they were happy with their personal relationships, and almost 40% of the individuals surveyed were unable to determine the level of their satisfaction with their relationships with family and friends. 14.22% (30 individuals) declared total satisfaction with their friendships. A half of the senior citizens surveyed declared that their friendships are good (54.03% – 114 individuals). One respondent rated their personal relationships and friendships as very poor. The Multi-Centre National Population Health Examination Surveys (WOBASZ) conduct-

ed showed that only 23% of females and 27% of males declared performance of physical activities [25]. The data analysis showed only the level of satisfaction of the leisure time use, without specifying exact activities. The results showed that 50% of the individuals surveyed were satisfied with the way they spent their leisure time, and 1/3 of the respondents were unable to determine the level of their satisfaction. An illness affects patients' physical and mental condition. Illness acceptance may mobilise patients to combat a diagnosed illness they suffer from [26]. The previous studies demonstrated the relationship between the illness acceptance degree and the respondents' age [27]. The author's own studies showed that the youngest patients demonstrated the highest level of illness acceptance (30 points), and the individuals above 85 years of age found this acceptance most difficult to achieve. In their study concerning 64 males and 36 females suffering from chronic cardiac failure, Uchmanowicz et al. did not demonstrate any significant differences between genders in terms of illness acceptance. The average AIS was 24 points for both males and females [28]. The author's own study included a reverse ratio of respondents, i.e. 133 females and 78 males. There were no significant differences between the values obtained from the females (28.0 points) and males (28.5 points). Both females and males declared indirect illness acceptance as per AIS. The study conducted by Rolka et al. encompassed 76% of respondents residing in urban areas (45% – a town populated by over 10 thousand inhabitants; 31% – a town populated by less that 10 thousand inhabitants), and 24% respondents from rural areas. The study demonstrated that respondents residing in smaller towns and rural areas declared an average illness acceptance level [27]. The results obtained by Moczydłowska et al. demonstrate that residents of rural areas declare a slightly lower level of illness acceptance than those living in urban areas, but both groups still demonstrate an average level of illness acceptance [9]. The respondents participating in the author's own studies resided in urban areas (without the population size specification) and rural areas (only 14% of all respondents). In both study groups, illness acceptance was at a moderate level amounting to 28 points. The available literature showed that the education level did not affect the illness acceptance among patients suffering from migraines [29]. The highest degree of illness acceptance among respondents qualified for artificial cardiac pacemaker implantation was declared by patients with secondary (31 points) and higher education (29 points). In contrast, patients with primary education experienced the greatest difficulty in accepting their illness. The studies conducted by Moczydłowska et al. demonstrate that married people's illness acceptance is at a full or moderate level, while widowers declared the greatest problems with such acceptance [9]. The author's own study results showed that married people fully accepted their illness (31 points), but the score achieved by single people (26 points) demonstrated that their illness acceptance was at a medium level. The results of the studies conducted by Robaszkiewicz-Bauakaz et al. among patients suffering from multiple sclerosis demonstrated a good level of illness acceptance by 56% of the respondents. 1/3 of these patients declared a medium level of illness acceptance, and approximately 10% of the respondents were unable to accept their illness [30]. The results of the previous studies conducted among patients with chronic obstructive pulmonary disease (COPD) showed that the degree of illness acceptance was 19 points on average, which showed indirect illness acceptance by those patients [31]. In the course of this study, approximately 46% of the respondents declared full illness acceptance, over 1/3 of the respondents declared moderate acceptance, and approximately 20% of the patients surveyed did not accept their condition. In the course of the study conducted among patients with the chronic obstructive pulmonary disease, Kupcewicz et al. demonstrated a low level of patients' acceptance of the necessity to adapt to the limitations caused by the illness and to the activities to be undertaken (1.59 ± 0.89) [31]. In this study, it was demonstrated that almost 40% of the respondents (83 individuals) had no problems accepting the limitations imposed by their condition. 30% of the patients surveyed (65 individuals) were unable to specify their acceptance level, and 5.69% (12 individuals) admitted having problems accepting the limitations imposed by their condition. While analysing the limitations regarding performance of favourite activities, it was determined that approximately 1/3 of the patients were not deprived of the possibility to perform such activities by their illness, and 11.85% (25 individuals) declared that their health condition contributed to such limitations. In the studies conducted among patients suffering from diabetes, Kurpas et al. demonstrated that approximately 2/3 of the respondents did not perceive themselves as a burden for their families as a result of their illness. The majority of those patients (58%) even declared their usefulness for their families [32]. The author's own analysis showed that the families of the majority of patients accepted their illness. Only 2.84% of those surveyed declared that their health condition made them a burden for their family and friends. Approximately 50% of the respondents disagreed with the suggestion that they might feel unwanted due to their health condition. In contrast, only 5% of the respondents (11 individuals) felt unwanted. An important factor that the researchers believe influences patients' non-acceptance of their illness is the belief that those around the patient are afraid of the further illness development and consequences [26]. However, the respondents surveyed did not share such concerns, as the majority disagreed with the statement. The available literature shows that the majority of patients suffering from the chronic obstructive pulmonary disease think that they will not be as self-sufficient as they would like to be (173) [31]. My study conducted among patients suffering from cardiology conditions and qualified for artificial cardiac

pacemaker implantation demonstrates that approximately 40% respondents feel that they will be fully self-sufficient in their everyday lives. In addition, half of the patients feel that they are fully adequate human beings despite their health condition.

CONCLUSIONS

1. The factors contributing to the fact that patients suffering from cardiology conditions assess their quality of life on a lower level than other patients include age, not having a spouse and lower education level.
2. The disease acceptance was best rated by younger people, those declaring to be married and those with a secondary or higher education.
3. Such factors as the patient's gender and place of residence are not a determinant of their quality of life and illness acceptance.
4. The higher illness acceptance level (AIS scale) demonstrates the statistically significant relationship with the better quality of life of the patients qualified for artificial cardiac pacemaker implantation during the COVID-19 pandemic period.

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ORIGINAL ARTICLE

Assessing the lifestyle habits and well-being of various specialities in Poland: A survey-based study

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ABSTRACT

Aim: This research aims to compare and contrast the lifestyle habits of physicians across various specialties through an in-depth exploration of topics such as dietary patterns, physical activity, stress levels, cognitive function, and overall well-being.

Material and Methods: A 15-question survey was distributed online through Google Forms among physicians from Wroclaw Medical University Hospital across various specialities including emergency medicine, internal medicine, surgery, and dermatology.

Results: Emergency medicine physicians struggle with hours of sleep, having poor eating habits, "fair" mental health, and stress levels at peak almost always. Internal medicine physicians and surgeons, despite having demanding specialties, reported the healthiest habits. Dermatologists reported 5-6 hours of sleep on average and high levels of stress, contrary to common belief that dermatology is a relaxed speciality.

Conclusions: The lack of hours of sleep can be addressed by having naps during long shifts; irregular eating habits can be solved by providing hospital-based meals. Moreover, emotional exhaustion can be solved by psychological counseling.

KEY WORDS

work-life balance, burn out, mental health, physician wellness

INTRODUCTION

Physician well-being has emerged as a central concern in healthcare discussions due to its direct correlation with clinical performance, patient outcomes, and professional sustainability. Burnout and lack of self-care among healthcare providers are increasingly viewed as a public health issue [1].These issues are often exacerbated by the unique demands of individual medical specialties, including long shifts, physical strain, and high workloads.

Emergency medicine is one of the most demanding specialities, which adversely affects the lifestyle habits of physicians. Physicians' lifestyle vary widely across the specialites, which include many challenges such as sleep deprivation, inadequate nutrition, limited physical activity, and heightened stress levels, which negatively impact their professional lives as well as their personal health thus leading to burn-out. In a specialty that is familiar with staff shortages and high patient volumes, it is important to understand these physician's daily routines and personal health practices and how they compare amongst different specialties, in order to identify negative trends and work towards creating a healthier system. Despite increasing awareness of the stressful work-life balance and burnout that physicians experience, in-depth data on their specific lifestyle habits remains limited.

AIM

The aim of the survey-based study is to assess and analyze lifestyle habits and overall well-being of physicians practicing in Poland across four different specialties. Points of comparison include daily routines, physical activity levels, sleep patterns, diet, and stress management strategies. The specialties that are compared include emergency medicine, internal medicine, surgery, and dermatology. By analyzing these factors, the aim is to gain insights into the lifestyle habits and identify the potential areas for improvement. While similar assessments have been done in Bahrain and Saudi Arabia [2, 3] limited data exists on Polish physicians, emphasizing the importance of collecting local data.

MATERIAL AND METHODS

A survey was conducted over a span of a four-week period where a Google form was distributed to 118 doctors at the Wroclaw Medical University Hospital. The doctors across various age groups were surveyed all the way from under 25 years to over 35 years old. The data was collected anonymously, and the Google Sheets as well as pie charts were used to analyze the results. Similarly to the Taif study, our survey was distributed electronically and covered domains such as diet, exercise, and sleep [1].

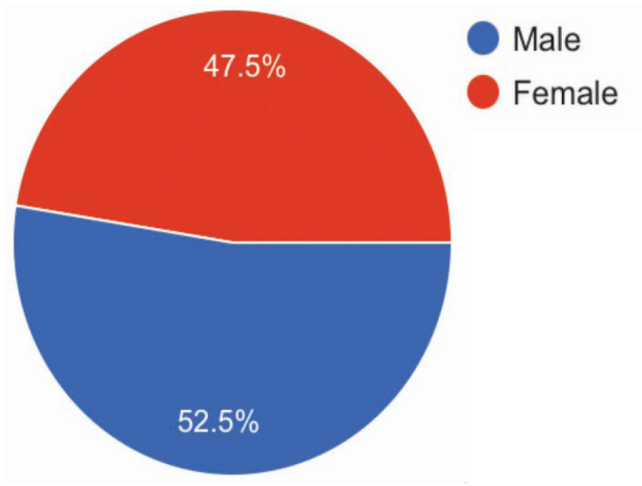

Fig. 1. Displays the percentage ratio of the gender

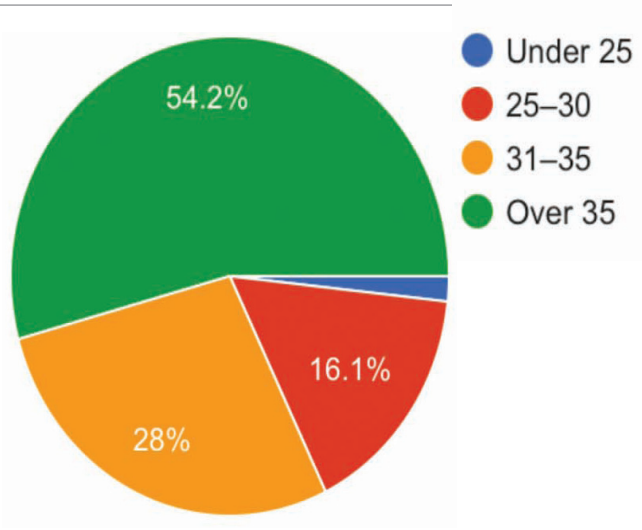

Fig. 2. Breakdown of the ages of the physicians

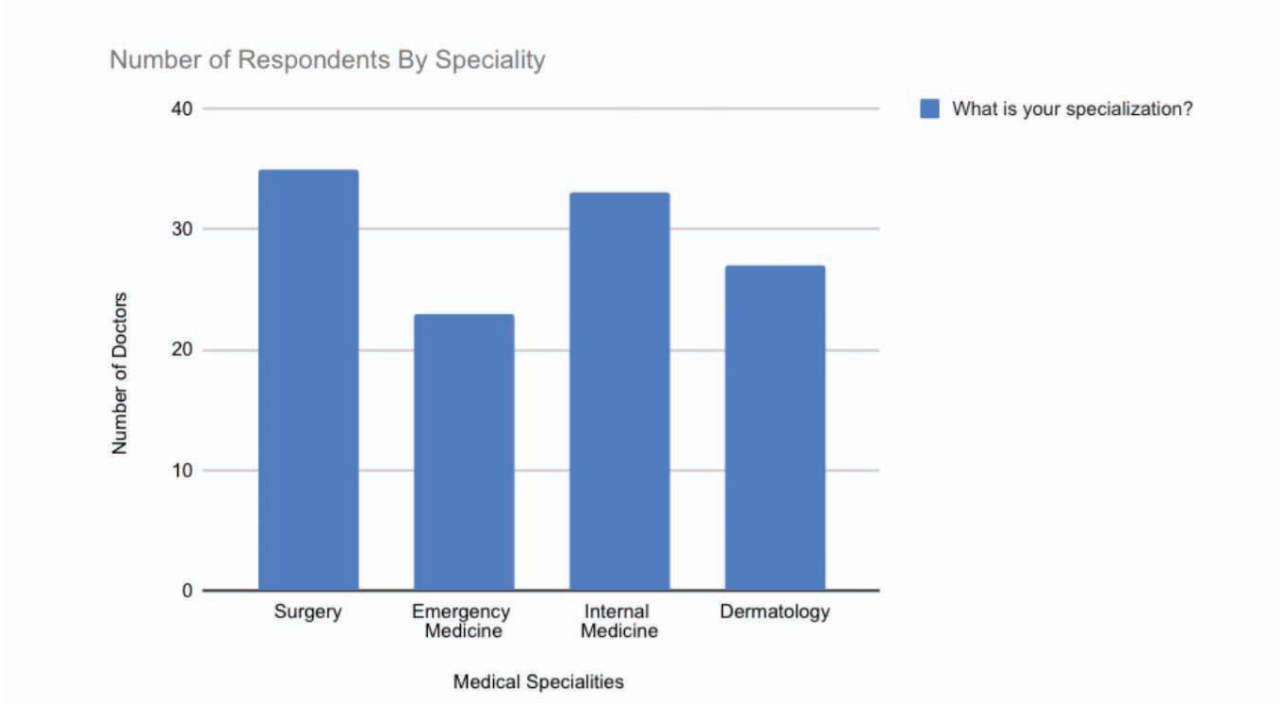

Fig. 3. Number of doctors that were surveyed as per the specialities

A more precisive overview of compared sections in our survey includes sections such as:

- Demographics including gender (Fig. 1), age (Fig. 2), and specialty (Fig. 3).
- Work-related variables including average weekly work hours and shift duration.
- Lifestyle habits including daily meal frequency, frequency of ordering takeout, physical activity levels, duration of sleep, and nicotine use.
- Mental health and stress management including self-reported stress levels, personal mental health rating, and strategies used to cope with occupational stress.

Data was stratified according to the four specialties we assessed and qualitative comparisons were made to highlight significant trends.

RESULTS

Firstly, the speciality of emergency medicine is where the doctors are overworked, understaffed, and have humongous line-ups of patients. The survey revealed that the doctors had irregular eating patterns, which led them to take out meals multiple times a week. Moreover, emergency medicine specialists were more overworked as opposed to other specialties. Emergency medicine being one of the busiest and most demanding specialites, Figure 4 demonstrates that the majority of the doctors-approximately 50% -practiced stress management techniques "occasionally," while almost a third never practised.

Secondly, internal medicine is a speciality requiring a wide array of knowledge, as it is such a broad speciality.

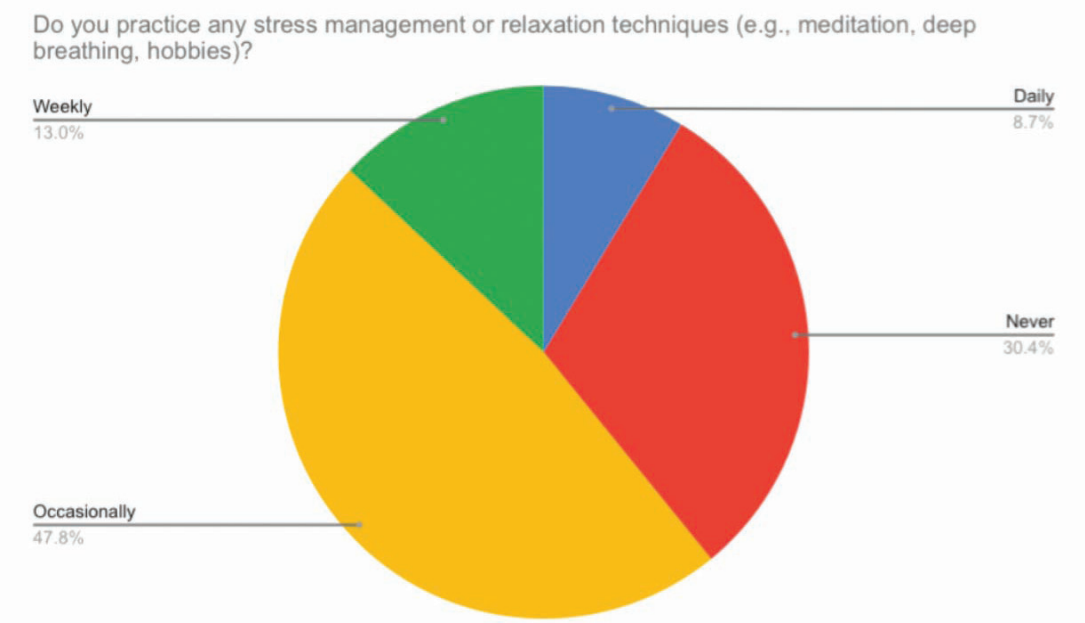

Fig. 4. Stress management techniques used by physicians

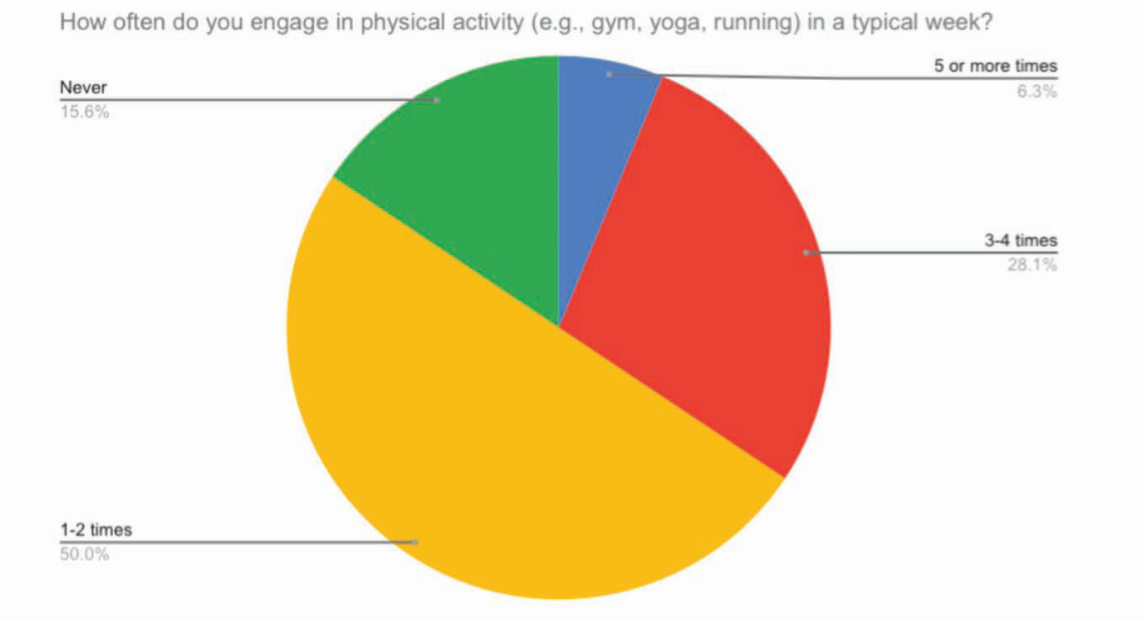

Fig. 5. Amount of physical activity performed by Internal Medicine specialists. According to the CDC, adults should engage in at least 150 minutes of moderate-intensity aerobic activity weekly [CDC, 2023]

Despite the fact that it is broad, the doctors in this speciality were able to do time management by engaging in physical activity 1-2 times a week as shown in Figure 5. Furthermore, a unique finding was that most doctors reported never using nicotine.

Thirdly in the field of surgery, one would assume that their unpredictable hours would translate to irregular eating habits. However, the survey revealed that over 50% of doctors consumed three meals a day, as shown in Figure 6. The demanding nature of surgeons' lifestyles consists of long working hours and often staying more than four hours past their scheduled shifts, longer than any other speciality.

Lastly, dermatology is a specialty that is a dream specialty, as it is assumed that doctors in this specialty have a perfect lifestyle. However, Figure 7 shows otherwise, that nearly a third of dermatologists slept around 5-6 hours. Other unique findings were that many reported experiencing high levels of stress, frequent nicotine use, and fair to poor mental health, contrary to the common belief that dermatology is a relaxed field.

DISCUSSION

This study illustrates the heterogeneity in lifestyle habits and well-being across medical specialties in Poland. According to our findings, Emergency medicine physicians

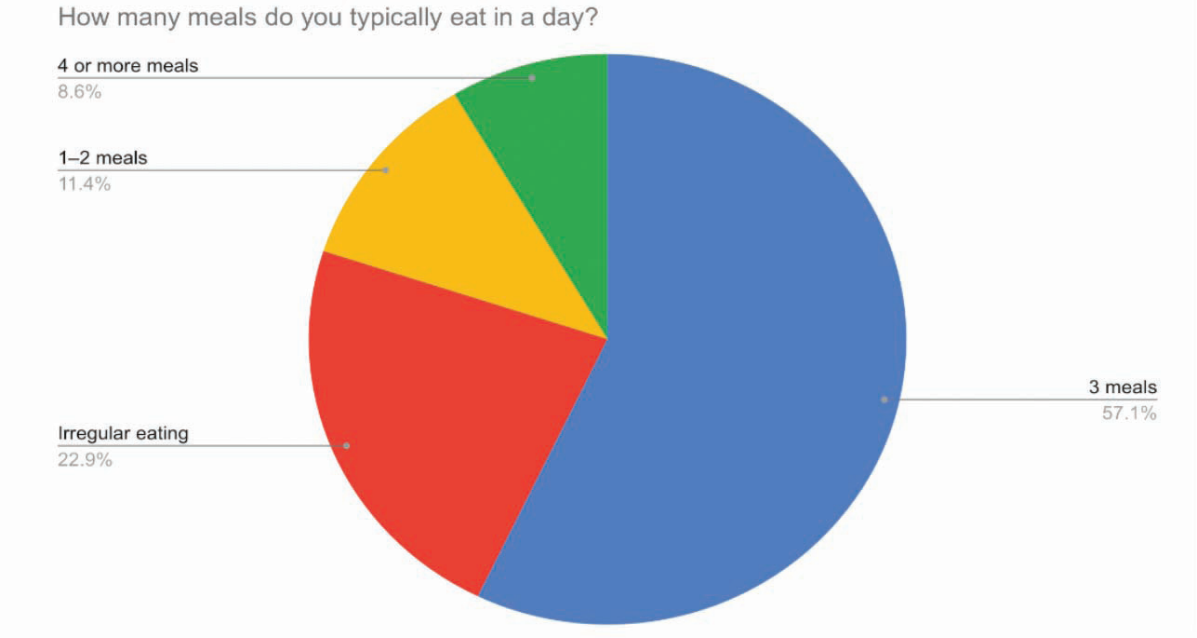

Fig. 6. Number of meals consumed by the surgeons

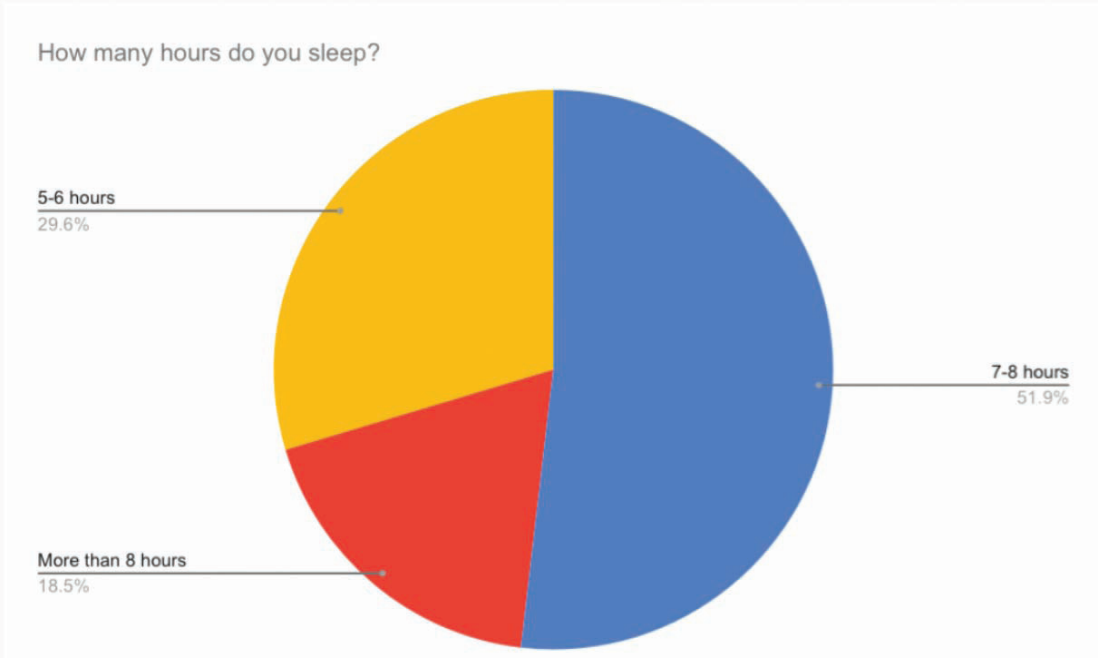

Fig. 7. Number of hours dermatologists sleep

are most vulnerable to the adverse effects of occupational stress, with poor sleep and poor nutrition habits likely contributing to burnout and increased risk for medical errors [4]. The situation is compounded by a lack of adequate recovery periods and the emotional toll of high-acuity care.

Conversely, internal medicine doctors showed relatively healthier habits and stress management, possibly reflecting greater personal initiative or better access to institutional support [5]. Yet, the cognitive demands of the specialty and concerns over patient complexity remain ongoing stressors.

Surgeons, typically deemed a very demanding specialty, displayed some positive lifestyle habits such as regular meals [6]. However, they additionally faced significant challenges in terms of time scarcity, overwork, and physical fatigue. The high-pressure environment and frequent overtime place them at increased risk of both physical and emotional exhaustion.

Dermatologists, often overlooked in discussions of burnout, demonstrated unexpected indicators of psychological strain and unhealthy coping mechanisms such as nicotine use [7]. These results suggest a need to investi-

gate the hidden stressors in outpatient and elective specialties, where mental health may silently deteriorate despite fewer acute emergencies.

As shown in other studies, poor lifestyle habits among physicians correlate with burnout and reduced patient care quality [8].

Recent policy discussions advocate for systemic changes to support physicians' well-being, aligning with our findings [1]. Without such reforms, the risk of burnout, cognitive fatigue, emotional exhaustion, and medical error in emergency medicine is unacceptably high. Incorporating institutional wellness policies as outlined by physician wellbeing toolkits could improve long-term outcomes [9].

CONCLUSIONS

This survey-based study highlights significant disparities in lifestyle habits and well-being among physicians across four major specialties in Poland, with emergency medicine standing out as in terms of occupational strain and its consequences. Emergency physicians face a uniquely high-stress environment characterized by unpredictable workloads, prolonged and erratic shifts, frequent exposure to acute trauma, and limited opportunities for rest or recovery. These conditions manifest in deeply concerning lifestyle indicators—most notably, severely inadequate sleep, highly irregular eating habits, high self-reported stress levels, and fair to poor mental health status.

The findings suggest that the structure and culture of emergency medicine, while vital to healthcare delivery, may be unsustainable without immediate institutional and policy-level interventions. These should include structured nap or rest breaks during long shifts, rotation systems to reduce shift-related circadian disruption, hospital-provided healthy meals, and protected time for mental health support, including counseling and debriefing following high-intensity cases. Although other specialties also demonstrated distinct challenges—surgeons with long hours and physical fatigue, dermatologists with surprising levels of hidden psychological strain, and internists grappling with cognitive burden—the acuity of risk in emergency medicine is both immediate and systemic.

Ultimately, this study underscores the need for tailored, specialty-specific interventions to improve the well-being of physicians in Poland.

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The influence of the human biological clock on the occurrence of sudden cardiac arrest

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ABSTRACT

Aim: To assess the frequency of sudden cardiac arrest cases in relation to the time, month, season and gender. In addition, the relationship between age and the time, month and season of SCA occurrence was examined. Finally, an attempt was made to link the occurrence of SCA with human biological cycles.

Material and Methods: The research material consisted of data on 1541 cases of sudden cardiac arrest obtained from the Department of Emergency Medical Services of the Podkarpackie Voivodeship Office in Rzeszów. In the statistical analyses, the Chi-square test, Phi test and Kramer's V were used.

Results: Men significantly more often than women experience sudden cardiac arrest 985 (64.8%) vs. 535 (35.2%). Moreover, men more often than women experience SCA at a younger age. In the daily perspective, cardiac arrest occurred most often between 9:00 and 11:59, the number of events was 278, which constituted 18.1% of the total number of cases. No statistically significant relationship between the age and the time of SCA occurrence was found. The season with the highest number of SCA cases was winter – 507 events were noted, which constitutes 32.9%.

Conclusions: The frequency of sudden cardiac arrest varies depending on the time of day, month or season. Based on the analyzed group of patients, it was found that cardiac arrests occurred most often in the morning hours and, on an annual basis, in the winter months. Based on the obtained results, it is not possible to clearly link the occurrence of SCA with the human biological clock.

KEY WORDS

biological clock, sudden cardiac arrest, biological cloces

INTRODUCTION

Sudden cardiac arrest is an undesirable and difficult to predict event, during which the effective contractile function of the heart muscle is lost. Within the first minute of SCA, the cardiac mechanism inhibits breathing and initiates a cascade of disorders leading to irreversible changes in the central nervous system caused by hypoxia [1]. The most common mechanism in the course of which sudden cardiac arrest occurs is ventricular fibrillation. Less frequently SCA occurs in the mechanisms of pulseless ventricular tachycardia (pVT), asystole and PEA [2]. The diagnosis of cardiac arrest in accordance with the guidelines should be made in every person who is unresponsive, breathless or breathes abnormally [3]. If SCA is confirmed, BLS or ALS protocols should be followed. Although the procedure for sudden cardiac arrest is clearly defined by the protocols of the European Resuctation Council, determining the probability of its occurrence is a more difficult task. An interesting area of knowledge that may have a potential impact on the risk of sudden cardiac arrest is biological rhythms and the human biological clock.

Biological rhythms are recurring biological phenomena that occur in humans, animals, and plants. They depend on both internal (genetically determined) and external (environmental) factors [4].

Biological rhythms are generated by the biological clock, which controls the circadian rhythm of internal processes in humans. The so-called circadian complex, which includes: the biological clock, afferent pathways and efferent pathways, is involved in measuring time during the day [6]. In mammals, the biological clock is located in the suprachiasmatic nuclei (SGN) of the hypothalamus. It acts as a master clock, which is the main rhythm generator. Afferent and efferent pathways are integral elements of the biological clock. Afferent pathways are responsible for synchronizing the work of the biological clock by supplying it with environmental signals, whereas, efferent pathways are responsible for transmitting information from the clock to the organ cells [7].

Circadian rhythms in humans participate in the adaptation of the human body to the environment by generating and coordinating many physiological mechanisms. The human body, using photoreceptors located on the retina, responds to light-dark cycles by synchronizing biological functions with the environment. The retina captures photons and transmits information via afferent neurons pathways to the suprachiasmatic nucleus of the hypothalamus (SCN). When the input information is integrated by the central clock, the expression of clock genes is activated, and consequently, hormonal and neuronal regulation in peripheral tissues occurs [8]. Similarly, other tissues equipped with their own circadian oscillators drive the rhythmic expression of clock genes. The expression of central clock genes and peripheral clocks exerts broad control

over numerous biological processes, including basic metabolic pathways [8,9]. The secretion of hormones such as melatonin, growth hormone, prolactin, testosterone, and aldosterone is dependent on the circadian rhythm [6].

Circadian activity of the autonomic nervous system is responsible for the rhythm of most parameters of the cardiovascular system. The activity of the sympathetic nervous system increases significantly during the day and decreases at night, contrary to the functioning of the parasympathetic system. The concentration of noradrenaline and adrenaline in blood serum is the highest in the morning hours and the lowest during sleep [5]. Almost all parameters of the cardiovascular system, such as blood pressure, heart rate, coagulation parameters or vascular endothelial activity change during the 24 hour period [9]. The release of catecholamines is reduced during the night, which leads to a decrease in blood pressure and heart rate, whereas, the highest level of catecholamines is observed in the morning, which allows the body to adapt to activity after waking up [10]. Moreover, in the last hours of sleep, the parasympathetic nervous system still dominates. However, periodically there are fluctuations and sudden increases in the activity of the sympathetic nervous system, which results in changes of blood pressure and heart rate [11]. As a result, in the morning and before noon, both the tension of the vascular musculature (including the coronary arteries) and the demand for oxygen in the heart muscle increase. This leads to an increased risk of coronary and vascular incidents [12,13].

The coagulation and fibrinolysis system is also subject to the cyclical influence of the biological clock [10]. One of the most important components of the hemostasis system are blood platelets, which participate in the coagulation process. Barcelo et al. prove that platelet activity fluctuates throughout the day, with the significant increase noted from 6:00 a.m. after waking up from sleep [14]. It should also be emphasized that a properly functioning coagulation system is in balance and should protect the human body against bleeding and clots formation.

AIM

The aim of the study was to assess the frequency of sudden cardiac arrest cases in relation to the time, month, season and gender. In addition, the relationship between age and the time, month and season of SCA occurrence was investigated. Finally, an attempt was made to link the occurrence of SCA with human biological cycles generated by the biological clock.

MATERIAL AND METHODS

The research material consisted of the data obtained from the Department of Emergency Medical Services and Emergency Notification of the Podkarpackie Voivodeship Office in Rzeszów. 1541 cases of SCA were analyzed. All the data obtained concerned the emergency interventions of medical rescue teams in patients with SCA. The study took into account the following parameters: date, time and place of SCA occurrence as well as age and gender of patients.

In statistical analyses, the Chi-square test for independence of variables was used as the basic test. The Phi test and Kramer's V were used to determine the strength of the relationship. Additionally, the Chi-square test was supplemented with tests performed using the exact or Monte Carlo method.

RESULTS

Based on the analyzed research material it was showed that sudden cardiac arrest occurred significantly more often in men than in women 985 (64.8%) vs. 535 (35.2%) (Table 1). Moreover, in the analyzed group of patients, men, compared to women, more often experience SCA, also at a younger age. The correlation coefficient was statistically significant ($p<0.001$) and was characterized by a fairly clear strength of association (Kramer's $V=0.293$) (Table 2). In the 24-hour period, cardiac arrests occurred most frequently between 9:00 and 11:59, the number of events in this time interval was 278, which constituted 18.1% of the total number of cases with SCA. SCA occurred least frequently between 3:00 and 5:59, this value was 82, which constituted 5.3% (Table 3). No statistically significant association was demonstrated between the age and the time of SCA incidence ($p>0.05$) (Table 4).

The month with the highest number of sudden cardiac arrests was December, with the occurrence of 191cases, which comprises 12.4%, while the fewest cases – 98, were recorded in June – which constituted 6.4% (Table 5).

Moreover, it was shown that older age of the study participants was associated with an earlier month in the year of SCA occurrence. The correlation coefficient was statistically significant ($p<0.05$), but was characterized by a negligible strength of the relationship (Kendall's Tau-c=-0.046) (Table 6). The season with the highest number of SCA cases was winter when 507 cases were recorded, which is 32.9%, while the fewest cases were recorded in summer – 321 (20.9%) (Table 7). At the same time, there was no correlation shown between the age of the patients and the season of SCA occurrence ($p>0.05$) (Table 8).

DISCUSSION

The results obtained after the analysis of 1541 cases of SCA showed that men experience sudden cardiac arrest almost twice as often as women. A similar relationship was observed in the group of young and middle-aged patients. In this age group, i.e. in the 30-59 age range, SCA was found to occur more than twice as often in men than in women.

A potential cause can be found in the anatomy and physiology of the hormonal and immune systems, which in women demonstrate more efficient functioning and better auto-regulation than in men. At the same time, there is no clear evidence conclusive of the

Table 1. Patient's gender of cardiac arrest

		Frequency	Percentage [%]	Percentage of significant values [%]
Significance	female	535	34,7	35,2
	male	985	63,9	64,8
	total	1520	98,6	100,0
No data	system data gaps	21	1,4	
Total		1541	100,0	

Tabel 2. Cross-tabulation: age *vs.* patient's gender of cardiac arrest

			Patient's gender		Total
			female	male	
Age	1-9	N	1	2	3
		[%]	0,2%	0,2%	0,2%
	10-19	N	6	4	10
		[%]	1,1%	0,4%	0,7%
	20-29	N	3	7	10
		[%]	0,6%	0,7%	0,7%
	30-39	N	9	42	51
		[%]	1,7%	4,4%	3,5%
	40-49	N	17	66	83
		[%]	3,2%	7,0%	5,6%
	50-59	N	29	119	148
		[%]	5,5%	12,6%	10,1%
	60-69	N	86	242	328
		[%]	16,3%	25,6%	22,3%
	70-79	N	125	249	374
		[%]	23,7%	26,3%	25,4%
	80-89	N	153	159	312
		[%]	29,0%	16,8%	21,2%
	From 90	N	98	55	153
		[%]	18,6%	5,8%	10,4%
Total		N	527	945	1472
		[%]	100,0%	100,0%	100,0%
Kramer's V	0,293	126,341a	9	0,000	0,000b
Coefficient	value	chi-square	df	p	Monte Carlo's p

positive or negative effect of androgens on the cardiovascular system and its different activation during the day [15]. The analyzed publications demonstrated the negative effect of increased testosterone and cortisol levels on the cardiovascular system, and the level of these hormones depends i.a., on the functioning of the biological rhythms generated by the biological clock [15-18]. The significantly higher incidence of sudden cardiac arrest in middle-aged men is a highly alarming phenomenon. The obtained results emphasize the need to implement early prevention programs and health education in order to minimize factors that af-

Tabel 3. Time of cardiac arrest

		Frequency	Percentage	Percentage of significant values
Significance	From midnight to 2 am.	83	5,4	5,4
	3 to 5	82	5,3	5,3
	6 to 8	242	15,7	15,7
	9 to 11	278	18,0	18,1
	12 to 14	235	15,2	15,3
	15 to 17	248	16,1	16,1
	18 to 20	226	14,7	14,7
	21 to 23	145	9,4	9,4
	Total	1539	99,9	100,0
Lack of data	system data gaps	2	0,1	
Total		1541	100,0	

Tabel 4. Cross-tabulation: time of cardiac arrest *vs.* age

			Age										Total
			1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	Above 90	
Time of the day	From midnight to 2 am.	N	0	1	1	3	1	13	20	23	15	4	81
		[%]	0,0%	10,0%	10,0%	5,9%	1,2%	8,7%	6,0%	6,1%	4,8%	2,6%	5,5%
	3-5	N	1	0	0	7	2	6	24	13	14	11	78
		[%]	25,0%	0,0%	0,0%	13,7%	2,4%	4,0%	7,2%	3,5%	4,5%	7,2%	5,3%
	6-8	N	1	1	1	7	17	20	50	60	56	18	231
		[%]	25,0%	10,0%	10,0%	13,7%	20,2%	13,4%	15,1%	16,0%	17,9%	11,8%	15,6%
	9-11	N	0	2	1	4	17	34	65	67	55	26	271
		[%]	0,0%	20,0%	10,0%	7,8%	20,2%	22,8%	19,6%	17,9%	17,6%	17,1%	18,3%
	12-14	N	1	1	4	4	12	23	57	55	42	24	223
		%	25,0%	10,0%	40,0%	7,8%	14,3%	15,4%	17,2%	14,7%	13,4%	15,8%	15,1%
	15-17	N	0	2	1	7	14	19	51	71	42	28	235
		%	0,0%	20,0%	10,0%	13,7%	16,7%	12,8%	15,4%	19,0%	13,4%	18,4%	15,9%
	18-20	N	1	2	0	14	9	20	40	42	64	26	218
		%	25,0%	20,0%	0,0%	27,5%	10,7%	13,4%	12,0%	11,2%	20,4%	17,1%	14,7%
	21-23	N	0	1	2	5	12	14	25	43	25	15	142
		%	0,0%	10,0%	20,0%	9,8%	14,3%	9,4%	7,5%	11,5%	8,0%	9,9%	9,6%
Total		N	4	10	10	51	84	149	332	374	313	152	1479
		%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Kendall's tau-c	0,027	0,019	1,392	0,164	0,159[c]
coeficient	value	Statistical error	aproximated T	p	Monte Carlo's p
Kramer's V	0,089	82,228[a]	63	0,052	0,051[b]
coefficient	value	Chi square	df	p	Monte Carlo's p

Tabel 5. Month of cardiac arrest

		Frequency	Percent [%]	Percent of significant values [%]
Significance	1	191	12,4	12,4
	2	161	10,4	10,5
	3	145	9,4	9,4
	4	116	7,5	7,5
	5	118	7,7	7,7
	6	98	6,4	6,4
	7	103	6,7	6,7
	8	120	7,8	7,8
	9	105	6,8	6,8
	10	125	8,1	8,1
	11	102	6,6	6,6
	12	155	10,1	10,1
	Total	1539	99,9	100,0
Lack of data	system data gaps	2	0,1	
Total		1541	100,0	

fect cardiovascular risk. An important aspect is also the socio-economic consequences caused by premature death or hospitalization and long-term rehabilitation that prevents gainful employment.

During the 24-hour period, sudden cardiac arrest occurred most frequently between 9:00 and 11:59 a.m., but a noticeable increase occurred already from 6:00 a.m. On the other hand, a significant decrease in the frequency of SCA occurred at night. In total, between 00:00 and 5:59 a.m, the number of cardiac arrest cases was 165, which comprises 10.7%, and between 6:00 and 11:59, it was 520, which constitutes 33.8% of all cases. This means a threefold increase in the frequency of SCA in the above mentioned time intervals. This may potentially be related to the simultaneous increase in the activity of the sympathetic nervous system and the decrease in the activity of the parasympathetic nervous system during the day, and the reverse relationship observed at night.

The hormone whose secretion is strongly related to the human circadian rhythm is cortisol, the greatest release of which is observed in the morning hours. However, the analyzed literature describes conflicting reports on the effect of cortisol on the occurrence of sudden cardiac arrest. That is why, this area of studies requires more detailed research. Nevertheless, it seems certain that its excessive secretion and high concentration may have an adverse systemic effect [12,13,16,18].

In the winter months (December, January, February), the number of emergency medical team interventions to SCA patients was the highest and amounted to 507 (32.9%). These months are characterized by lower temperatures and shorter days with low access to sunlight. As a result, the human body increases the synthesis of hormones such as catecholamines and aldosterone, which leads to an increase in vascular resistance, and higher blood pressure values.

The influence of low temperatures also seems to be significant, which, through increased activation of the adrenergic system, leads to an increase in blood pressure and heart rate. As a result, these factors may indirectly be associated with more frequent exacerbations of cardiovascular diseases and the occurrence of SCA cases [12, 13, 15]. Considering the higher frequency of SCA during the day, actions should be taken to increase the number of available rescue teams or to ensure an adequate number of medical personnel in emergency departments, as well as early response teams in hospitals. It seems equally important to conduct actions aimed at improving knowledge and awareness of the alarm symptoms from the cardiovascular system that may herald the occurrence of SCA. Moreover, it should be noted that factors such as chronic diseases or medical history were not analyzed in this study due to the lack of this information in the obtained data. In future studies, the possibility of determining hormones such as cortisol in the blood should also be considered.

It should be emphasized that in the presented study factors such as comorbidities, medications used or other cardiovascular risk factors were not analyzed due to the lack of this information in the obtained data. It can also be assumed that they may affect the circadian pattern of SCA occurrence. Despite the observation of certain relationships between the time of SCA occurrence and literature data on the circadian rhythm of hormone secretion affecting the cardiovascular system, it is not possible to clearly link the occurrence of SCA with the human biological clock based on the obtained data. In

Table 6. Cross-tabulation: month *vs.* age of cardiac arrest

		Age										Total
		1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	From 90	
Month 1	N	1	1	2	6	16	18	38	38	41	24	185
	%	25,0%	10,0%	20,0%	11,8%	19,0%	12,1%	11,4%	10,2%	13,1%	15,8%	12,5%
2	N	0	0	4	2	4	15	31	39	39	20	154
	%	0,0%	0,0%	40,0%	3,9%	4,8%	10,1%	9,3%	10,4%	12,5%	13,2%	10,4%
3	N	0	1	1	2	10	10	27	39	28	22	140
	%	0,0%	10,0%	10,0%	3,9%	11,9%	6,7%	8,1%	10,4%	8,9%	14,5%	9,5%
4	N	0	2	1	5	7	11	30	25	22	9	112
	%	0,0%	20,0%	10,0%	9,8%	8,3%	7,4%	9,0%	6,7%	7,0%	5,9%	7,6%
5	N	0	0	0	4	5	9	21	33	22	17	111
	%	0,0%	0,0%	0,0%	7,8%	6,0%	6,0%	6,3%	8,8%	7,0%	11,2%	7,5%
6	N	0	0	0	4	5	10	22	23	19	10	93
	%	0,0%	0,0%	0,0%	7,8%	6,0%	6,7%	6,6%	6,1%	6,1%	6,6%	6,3%
7	N	0	1	1	3	8	8	27	23	21	11	103
	%	0,0%	10,0%	10,0%	5,9%	9,5%	5,4%	8,1%	6,1%	6,7%	7,2%	7,0%
8	N	0	2	1	3	11	18	23	32	20	7	117
	%	0,0%	20,0%	10,0%	5,9%	13,1%	12,1%	6,9%	8,6%	6,4%	4,6%	7,9%
9	N	0	0	0	2	2	13	28	24	21	8	98
	%	0,0%	0,0%	0,0%	3,9%	2,4%	8,7%	8,4%	6,4%	6,7%	5,3%	6,6%
10	N	0	1	0	9	6	8	27	32	31	5	119
	%	0,0%	10,0%	0,0%	17,6%	7,1%	5,4%	8,1%	8,6%	9,9%	3,3%	8,0%
11	N	1	0	0	3	4	11	27	27	18	8	99
	%	25,0%	0,0%	0,0%	5,9%	4,8%	7,4%	8,1%	7,2%	5,8%	5,3%	6,7%
12	N	2	2	0	8	6	18	31	39	31	11	148
	%	50,0%	20,0%	0,0%	15,7%	7,1%	12,1%	9,3%	10,4%	9,9%	7,2%	10,0%
Total	N	4	10	10	51	84	149	332	374	313	152	1479
	%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Kendall's tau-c	-0,046	0,019	-2,400	0,016	0,015[c]
coefficient	value	Stst. error	Aproxi-mated T	p	Monte Carlo's p

Table 7. Season of occurrence of cardiac arrest

		Frequence	Percentage [%]	Percent of significant values [%]
Significance	Spring (3 do 5)	379	24,6	24,6
	Summer (6 do 8)	321	20,8	20,9
	Autumn (9 do 11)	332	21,5	21,6
	Winter (12 do 2)	507	32,9	32,9
	Total	1539	99,9	100,0
Lack of data	system data gaps	2	0,1	
Total		1541	100,0	

Table 8. Cross-tabulation: season *vs.* age of cardiac arrest

			Age										
			1-9	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**From 90**	**Total**
Season of the year	Spring (3-5)	N	0	3	2	11	22	30	78	97	72	48	363
		[%]	0,0%	30,0%	20,0%	21,6%	26,2%	20,1%	23,5%	25,9%	23,0%	31,6%	24,5%
	Summer (6-8)	N	0	3	2	10	24	36	72	78	60	28	313
		[%]	0,0%	30,0%	20,0%	19,6%	28,6%	24,2%	21,7%	20,9%	19,2%	18,4%	21,2%
	Autumn (9-11)	N	1	1	0	14	12	32	82	83	70	21	316
		[%]	25,0%	10,0%	0,0%	27,5%	14,3%	21,5%	24,7%	22,2%	22,4%	13,8%	21,4%
	Winter (12-2)	N	3	3	6	16	26	51	100	116	111	55	487
			75,0%	30,0%	60,0%	31,4%	31,0%	34,2%	30,1%	31,0%	35,5%	36,2%	32,9%
Total		N	4	10	10	51	84	149	332	374	313	152	1479
		%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Kendall's tau-c	-0,002	0,022	-0,105	0,916	0,912[c]
coeficient	Value	Stat.error	Aproxi-mated T	p	Monte Carlo's p
Kramer's V	0,083	30,330[a]	27	0,300	0,295[b]
coefficient	value	Chi-kwadrat	df	p	Monte Carlo's p

future studies, the circadian profile of hormone levels, especially cortisol, should be determined, with the emphasis on the patients at high risk of sudden cardiac events. However, due to the unpredictable nature of SCA, this will be a very difficult task.

CONCLUSIONS

Based on the data obtained, it is not possible to clearly link the occurrence of SCA with the human biological cycles generated by the biological clock. However, this area of knowledge seems to be interesting and requires further, more detailed research.

In the study, after analyzing 1,541 cases of SCA, it was found that SCA occurred in men almost twice as often as in women. A similar relationship was observed in the subgroup of young and middle-aged patients, i.e. in the 30-59 age range.

Sudden cardiac arrest occurred most often in the morning hours. No statistically significant relationship was found between the age and the time of SCA occurrence. The months with the highest number of sudden cardiac arrests were the winter ones.

The obtained results indicate the need for early detection of dysfunctions and diseases of the cardiovascular system, and consequently, undertaking appropriate preventive medical interventions. In addition, efforts aimed at increasing the health awareness of society and the importance of preventing cardiovascular diseases should be intensified, especially among young and middle-aged men. At the same time, by leading a lifestyle consistent with circadian rhythms, which involves proper sleep hygiene, access to natural sunlight and stress reduction, we can try to limit the negative consequences of a disturbed biological clock on our health.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

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Anaphylaxis as complication of dental local anaesthesia in the light of emergency medicine – literature review

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ABSTRACT

Local anaesthesia precedes most of the procedures performed in dental practices nowadays. Solutions injected into the tissues contain either several chemical compounds or their intermediates which may present allergenic properties. While allergic reactions to local anaesthetics (LA) are relatively rare, they can be life-threatening and often present challenges in clinical management. Moreover, it is often misdiagnosed due to overlapping symptoms with toxic or psychogenic reaction. This review explores the mechanisms, prevalence, and management of anaphylaxis in dental anaesthesia, triggered by LA, focusing on recent trends and recommendations. LA are classified into esters and amides, each metabolised differently, with esters producing para-aminobenzoic acid, a known allergen. Preservatives like methylparaben and metabisulfite further contribute to allergenic potential. Current management protocols emphasize early adrenaline administration and airway support. Cyclic training of practitioners and the following of updated management guidelines are essential to ensure optimal patient care. The study underscores the importance of raising awareness among dental professionals about the potential risks associated with local anaesthesia and the necessity of incorporating effective management protocols in clinical practice.

KEY WORDS

dental anaesthesia, local anaesthetics, anaphylaxis, adverse reaction, complication

INTRODUCTION

Local anaesthetics (LA) are medications widely used in every clinical dental practice on account of the fact that diminishing pain associated with performing dental procedures is a standard. However, there are several adverse reactions that might occur during the injection, as well as following it. According to the recommendations of the International Committee on Harmonisation from the WHO Collaborating Centres for International Drug Monitoring, a serious adverse reaction is an adverse effect that is fatal or life threatening, that causes hospitalisation or prolongation of hospitalisation, or permanent or significant disability. On the other hand, the nature and severity of unexpected drug reactions is not consistent with data contained in domestic labeling or market authorization of the drug [1]. Adverse reactions reported in the literature concern both medications, including lidocaine, prilocaine, mepivacaine, and their components, such as methylparaben or metabisulphite [2, 3].

According to chemical structure, LA can be divided into two groups: esters and amides. Each of the anaesthetics has 3 main parts forming their molecules: lipophilic aromatic ring, intermediate ester or amide chain linkage, and hydrophilic tertiary amine [4, 5]. No matter the group, all LA present the same mechanism of action, however different metabolism [6, 7]. These medications inhibit the conductance of sodium through the sodium channels located in the cell membrane of neurons. By disordering the lipid bilayer they lead to the impeding of the sol-to-gel transition and thus conformational shifts of the sodium channels [8].

Amides, with one exception, are transformed in the liver by hepatic microsomal enzymes into water soluble metabolites and thereafter excreted by the kidney [9]. Articaine is the only amide-type LA that is primarily metabolised by plasma esterases in the blood plasma [7, 10, 11]. On the other hand, esters are hydrolyzed by pseudocholinesterase in the blood plasma [5, 6, 12]. On this basis, the use of amide-type LA should be considered with caution in patients with liver diseases, such as hepatitis or cirrhosis. Similarly, it should be taken into account when selecting ester-type LA for patients suffering from congenital pseudocholinesterase deficiency [8]. There are also several intermediates of LA solutions, which might possibly induce hypersensitivity reactions. The metabolism of esters leads to the product, which is a potential allergen – para-aminobenzoic acid (PABA), while amides are free of such by-products during their conversion. However, there are some compounds used as additives to anaesthetic solutions that present allergenic properties, such as methylpa-

raben and metabisulfite [3, 5, 13]. The first one is included because of its antibacterial function, however nowadays it is only added to multidose vials, no longer to single-dose vials or cartridges. The latter is an antioxidant, maintaining the vasoconstrictors in an active molecular form [14, 15]. In this regard, LA solutions with such preservatives should be used carefully or withheld in patients with food allergies associated with sulfites [16].

In most of the cases, LA are used in conjunction with above mentioned vasoconstrictors (VC), such as catecholamine type epinephrine and norepinephrine or felypressin, a synthetic analogue of vasopressin. They are included in anaesthetic solutions because of their ability to improve hemostasis, prolong the duration of anaesthesia and reduce the toxicity of LA [17-19].

Epinephrine reduces peripheral blood vessels' diameter by activating α1 receptors. The rise in blood pressure, as an effect of heart rate increase, is the effect of β1 receptor stimulation. Additionally, it presents a vasodilatory effect in muscles and internal organs by interacting with β2 receptors [20, 21]. In contrast, felypressin is claimed to show no direct effect on the myocardium function and thus is preferred among patients suffering from cardiovascular diseases in order to decrease systemic adverse reactions [18, 19].

Anaesthetic solutions can be applied in dentistry via traditional syringes, computer-controlled local anaesthesia delivery systems or by spray, according to the type of dental anaesthesia [22, 23]. Several main methods can be distinguished: superficial, infiltration or nerve blocks. Superficial anaesthesia is performed mainly by spray or gel. On the other hand, infiltrative anaesthesia and nerve blocks require the use of the needle in order to deposit the solution in the proper site of the tissues. Modern dentistry offers plenty of different devices, as well as additives, focusing on maximising comfort and efficacy of the treatment procedures. They might include procedures such as warming, buffering of the anaesthetic or creating the pressure around the injection site [20, 24, 25].

AIM

The aim of the study is to present the problem of anaphylaxis, arising from the local anaesthesia in dentistry, focusing on the recent trends and recommendations. The paper shows the importance of the issue in relation to changes in the awareness of physicians throughout different continents along with management algorithms.

REVIEW AND DISCUSSION

The procedure of dental local anaesthesia itself, as well as anaesthetic solutions injected into the tissues might induce several side effects in the organism. Reactions to LA can be classified as allergic, toxic or autonomic [26]. The most severe form of allergic reactions that is life-threatening is anaphylaxis, which might include a range of clinical signs and symptoms. According to World Allergy Organization Anaphylaxis Guidance from 2020 it is defined as a serious systemic hypersensitivity reaction that is usually rapid in onset and may cause death. It can be considered as the highly likely diagnosis when any one of the criteria is fulfilled. First criterion is acute onset of an illness (within minutes to several hours) involving the skin, mucosal tissue, or both (e.g., generalized hives, pruritus or flushing, swollen lips-tongue-uvula), and at least one of the following, which are: respiratory compromise (e.g., dyspnea, wheeze-bronchospasm, stridor, reduced peak expiratory flow, hypoxemia); reduced blood pressure or associated symptoms of end-organ dysfunction (e.g., hypotonia, syncope, incontinence); severe gastrointestinal symptoms (e.g., severe crampy abdominal pain, repetitive vomiting), particularly after exposure to non-food allergens. The second, alternative criterion involves acute onset of hypotension, bronchospasm, or laryngeal involvement occurring within minutes to several hours after exposure to a known or highly probable allergen for that patient, even in the absence of typical skin involvement.

Severe anaphylaxis is characterised by potentially life-threatening compromise in airway, breathing and/or the circulation, and may occur without typical skin features or circulatory shock being present [27]. The clinical manifestations of anaphylaxis often emerge within minutes; anaphylaxis is classified according to its severity as four grades as follows: Grade I: cutaneous–mucous signs, grade II: cutaneous–mucous signs with accompanying cardiovascular and/or respiratory signs such as tachycardia and bronchial hyperreactivity/cough, grade III: cardiovascular collapse with multivisceral signs such as bronchospasm and grade IV: cardiac arrest [26].

Besides the major form of anaphylaxis, three subtypes may be distinguished, as follows. Persistent, highly probable when it extends over at least four hours, refractory, highly suspected when not resolved by appropriate medication and biphasic [28]. It belongs to the type 1 hypersensitivity reactions, also known as immediate reaction, characterised by smooth muscle contraction, along with a rise in vascular permeability, vasodilatation and thus, oedema, as an answer to a rapid (5-30min) release of proimflammatory cytokines from immunoglobulin E (IgE) mediated mast cell degranulation [5, 26, 28). It is associated with IgE-mediated release of antibodies against a soluble antigen. It is important to note that there are also infrequently reported cases in which only one system is primarily affected, as usually such chemical compounds induce responses from cardiovascular system, respiratory tract, gastrointestinal tract along with dermis. Moreover, anaphylaxis is rarely an initial reaction during the first exposure to an allergen [1, 28]. During the primary sensitisation stage the host is exposed to the antigen and it is asymptomatic. Antigen presenting cells (APCs) present the allergen to the T-cells, which promote the production of IgE antibodies by B-cells. These antibodies bind with the receptors on mast cells and basophils, which release histamine, proteolytic enzymes and other proinflammatory factors. Subsequently when the pre-sensitized host is reintroduced to the antigen a symptomatic reaction occurs [5, 26, 28]. Consequently, vigilance for hypersensitiv-

ity symptoms should be maintained while administering LA. If a rapid response is observed, referring patients for skin prick tests (SPTs) intradermal or subcutaneous placement tests, and/or drug provocative challenge testing (DPT) by an allergist is recommended in order to avoid the risk of future anaphylactic reaction [29, 30, 31]. Routinely, the first test performed is SPT, during which the allergen is injected into superficial layers of the skin on the forearm. It is evaluated as positive if a wheal and flare occurs. In case of systemic reaction, adequate treatment is implemented. If the test was evaluated as negative, the solution containing the allergen is injected into deeper layers of the dermis in intradermal or subcutaneous placement tests[30, 31]. Finally, in DPT, described by many specialists as the gold standard for investigation of drug hypersensitivity reactions, a commercial solution of the allergen is applied in the way as similar as possible to the situation, when the hypersensitivity reaction occurred. However, an individual risk-benefit evaluation is crucial, as this method might have possible, concerning side effects [29].

According to literature anaphylaxis accounts for less than 1% of complications associated with dental local anaesthesia [5, 26, 30, 32]. Fuzier et al. observed allergic reactions to represent 19,4% of all adverse reactions to LA, while anaphylaxis made up 14% of them and therefore 2,7% of the total of complications. All of the five LAs (lidocaine, bupivacaine, mepivacaine, ropivacaine and levobupivacaine) included in the study were involved in allergic manifestations [1]. It is more common among ester-type LA [32], which are one of the most allergenic agents, used in dental practice, after latex, non-steroidal antiinflammatory drugs and penicillin-type antibiotics [6]. However in the group of amide-type LA it is noted most often with lidocaine [33]. With regard to several studies, such adverse reactions are observed more frequently among women than men (61,53% vs. 38,46% or 70% vs. 30%) [1, 31].

Anaphylaxis represents type 1 hypersensitivity reactions classified by Gell and Coombs. The contact of IgE antibody with the allergen leads to the release of mediators, such as histamine from the mast cells and basophils. These chemical compounds cause a sudden increase in vascular permeability and smooth muscle contraction. Because of that, symptoms such as angioedema, bronchospasm, cardiovascular depression or shock might occur [5, 28, 34, 35]. There are 5 grades of severity of anaphylactic reaction, including cutaneous symptoms, measurable but not life-threatening symptoms, life-threatening symptoms, cardiac and/or respiratory arrest, and death [36]. Sometimes it is observed that other complications, such as intravascular injection, toxic overdose, idiosyncrasy or psychogenic reactions might be mistaken for a true allergic reaction [29]. Latex proteins may mimic allergic reactions to LA as well [37]. Such a reaction is mainly observed within the first 30 minutes after the administration of LA [5]. There are notable changes in IgE antibody levels throughout the process. In the first hour after the exposure to an antigen a decrease is observed, followed by a distinct increase, remaining for 72 hours post exposure [29]. When patients experience palpitations, sweating, lightheadedness, or hypotension, it is important to rule out whether these signs represent an autonomic response or a true allergic reaction [26].

The basis of management is the correct and early diagnosis, followed by the elimination of the allergen if it is possible. The primary treatment is adrenaline. In the case of mild or moderate hypotension 0,2μg/kg (5-10 μg) of epinephrine should be administered intravenously or 0,5mg intramuscularly [28, 35]. The proper dose of adrenaline for cardiovascular collapse is 0,1-0,5mg, similarly administered intravenously. At the next step, crystalloid fluids (2-4l) along with vasopressors are recommended to manage the hypotension. The treatment for respiratory symptoms includes at first point airway securement, followed by 100% oxygen, bronchodilators, and glucocorticoids. If the allergy is limited to urticaria or contact dermatitis, antihistamine or steroid therapy is performed [3, 7, 35].

The awareness of physicians in managing anaphylaxis as an adverse effect emphasises the importance of the problem. According to Smereka et al. among 422 dental practitioners, 55,13% did not feel competent in the treatment of anaphylactic shock [38]. In another study, 40% of 153 undergraduate students and interns believed antihistamines are first-line medications used in anaphylactic shock [39]. Such findings illustrate the scale of the issue and highlight the deficiencies in the management of adverse reactions that occur rarely in everyday practice. According to the fact that anaphylaxis is often challenging to recognise and its occurrence represents such a minor percentage of the clinical cases encountered, an introduction of staff training and repositioning epinephrine autoinjectors might enhance the management of this re action [28, 30]. Kishimoto et al. found that implementing a training programme, using medical simulations software enabled physicians to significantly improve the diagnosis and treatment of anaphylactic shock in contrast to the beginning of the study, without any such training programmes previously [40]. Such results present effective possibilities to expand the awareness, along with the management algorithms incorporation and sufficient treatment process. Further studies focusing on implementing training programmes and workshops for practitioners and recalling the management algorithms theoretically are crucial in order to provide sufficient dental care. Similarly, future research focusing on emphasising the current knowledge of physicians is recommended in order to raise the awareness and adjust supplementary courses to the needs of each country and region.

CONCLUSIONS

Anaphylaxis associated with dental local anaesthesia is a rare occurrence, however crucial to diagnose and treat. The increase in awareness of the patients is important, especially at the stage of taking a medical history. Future directions should emphasize interdisciplinary col-

laboration between dentists, allergists, and emergency physicians to optimize prophylactic strategies, such as pre-procedural IgE testing or drug provocation trials in high-risk patients. Research into novel hypoallergenic anesthetic agents and preservatives, alongside regional audits of anaphylaxis management compliance, could further reduce morbidity. Ultimately, fostering a culture of vigilance, continuous education, and adherence to evidence-based guidelines will ensure that dental practices remain prepared to address this rare but potentially catastrophic complication, safeguarding patient safety in an evolving clinical landscape.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

Healthcare during the war in Ukraine

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ABSTRACT

The aim of this study is to analyze the state of medical care provision during the war in Ukraine. To conduct a comprehensive analysis of the situation in Ukraine's healthcare system over nearly three years of war, we performed a content analysis of sources dedicated to studying the state of the medical sector under wartime conditions in Ukraine. Russia's failed attempt to capture Kyiv altered the nature of its military actions, leading to systematic and targeted bombings of Ukraine's civilian infrastructure, including healthcare facilities. Despite the ongoing full-scale war, efforts to restore and reconstruct medical infrastructure continue, along with initiatives to ensure energy independence for primary healthcare facilities. Currently, many hospitals are equipped with shelters where doctors can provide the necessary, qualified medical assistance. Urgent and complex surgical procedures, planned transplantations, and blood donation services continue. The Medical Guarantees Program (MGP) not only remains operational during the war but also introduces new service packages. The development of a rehabilitation system in the healthcare sector continues, particularly for war victims and veterans. Significant attention is given to psychological support for the population. The National Mental Health and Psychosocial Support Program has been launched to build an effective system of high-quality and accessible mental health services. Ukraine's healthcare system continues to function under wartime conditions, demonstrating resilience and adaptability. Despite the challenges, it responds rapidly to the needs and demands of the population.

KEY WORDS

war, Ukraine's healthcare system, mental health, medical rehabilitation

INTRODUCTION

Through blatant political blackmail and the element of surprise, Russian military forces launched a full-scale war against Ukraine on February 24, 2022. At the time, Ukraine was in the midst of implementing healthcare system reforms: the National Health Service of Ukraine (NHSU) had recently been established to implement state policy in the area of financial guarantees for public healthcare services, and the reorganization of primary medical care facilities (outpatient clinics, paramedic-midwifery stations, medical points, and offices) had begun.This period coincided with the severe challenges posed by the COVID-19 pandemic. The full-scale war inflicted significant damage on Ukraine's healthcare system, including the destruction of medical infrastructure, the inability to maintain preventive and treatment standards, and shortages of medical personnel in certain regions. Disruptions in logistics further hindered the timely and complete provision of medical supplies to the population.As a result of the large-scale displacement of people both within and outside the country, the demand for medical services shifted significantly across different regions, exacerbating disparities in resource distribution within the healthcare sector [1].

The conditions for providing medical care in Ukraine were further complicated by the destruction of energy infrastructure, leading to the risk of power outages in operating rooms, intensive care units, and maternity wards. The war has had a general negative impact on the nation's health, increasing the number of injuries and traumas among both military personnel and civilians, thereby further straining the healthcare system [2].

Damage to and destruction of medical infrastructure, mass displacement of people, shortages of medical specialists, and disruptions in logistics have all impeded the timely and full provision of medical resources. Many healthcare facilities have faced critical shortages of essential medicines and equipment [3].

AIM

The aim of this study is to analyze the state of medical care provision during the war in Ukraine.

MATERIAL AND METHODS

To conduct a comprehensive analysis of the situation in Ukraine's healthcare system over nearly three years of war, a content analysis was performed onsources dedicated to studying the state of the medical sector under wartime conditions in Ukraine.

REVIEW

Russia's failed attempt to capture Kyiv altered the nature of its military actions. The aggressor launched systematic and targeted bombings of Ukraine's civilian infrastructure, including healthcare facilities.As of early December 2024, 1,878 medical facilities had been damaged, and 289 had been completely destroyed. The regions with the highest losses of hospitals and healthcare institutions include Kharkiv, Donetsk, Mykolaiv, Kyiv, Chernihiv, Dnipropetrovsk, Kherson, and Zaporizhzhia.

Obtaining up-to-date and comprehensive data on the extent of destruction in temporarily occupied territories remains impossible at this time.Despite the ongoing aggression, local governments managed to fully restore 565 medical facilities and partially restore 370. The regions with the highest numbers of restored facilities are Mykolaiv, Dnipropetrovsk, Kyiv, Kharkiv, Kherson, and Chernihiv. This applies to medical institutions in liberated territories as well as those that suffered only minor damage, such as broken windows, damaged roofs, and facade destruction [4].

The World Health Organization (WHO) representative in Ukraine, Jarno Habicht, cited data from the updated HeRAMS Ukraine report, which comprehensively reflects the operational status of healthcare facilities [5]. However, there are no exact figures on how many people were left without medical care, as the data varies across different regions.The demand for medical services has generally increased, especially in winter and due to damage to critical infrastructure. Power and water supply disruptions, evacuations, and structural damage have reduced the number of functioning healthcare facilities, particularly in the Kharkiv, Kherson, and Donetsk regions, where many facilities were damaged or became non-operational.

In the first months of the invasion, nearly one-third of the population faced difficulties in accessing medications due to closed pharmacies, disrupted supply chains, and delays in pharmaceutical shipments at border checkpoints. The transportation of certain medicines, raw materials for their production, and medical supplies required adherence to specific temperature conditions, which was difficult to maintain. In addition, attacks on healthcare facilities made people feel unsafe when seeking medical assistance.

SITUATION OF THE HEALTHCARE SYSTEM IN UKRAINE

Ukraine's healthcare system is functioning, strengthening, and – despite everything – quickly responding to needs and challenges. In frontline areas, where the need is greatest, humanitarian organizations also contribute to providing assistance. As a result, access to medical care is improving.

Since the attacks on energy infrastructure in October 2022, there has been a need for generators and support for energy efficiency. This has created significant difficulties, especially duringthe cold season, as shorter daylight hours increase the risk of falls and injuries. Additionally, many medicines and food products need to be stored under specific conditions, such as refrigeration. Attacks on heating and power plants often lead to water shortages, which in turn cause sanitation and hygiene issues, and increase the risk of infectious diseases. Currently, all medical institutions in Ukraine that provide inpatient and emergency care are equipped with backup power sources to ensure continuity of care during electricity outages.

Where possible, medical facilities are being restored. One of the solutions for frontline areas is modular primary healthcare clinics. Additionally, at the initiative of the Ministry of Health of Ukraine (MOH), mobile pharmacies have been launched. The WHO, along with numerous partners, provides medicines that primary care doctors distribute to patients, but this is a temporary solution, usually as part of a humanitarian response [6].

Approximately 6,253,700 people have left Ukraine, and many more have been internally displaced [7]. This means that citizens who relocated to other regions of Ukraine sought access to medical services intheir new places of residence, which led to an overload of the healthcare system. Some people refused treatment altogether or postponed it, leading to chronic disease progression and complications. At the same time, many free medical platforms, chatbots, and other services emerged, allowing doctors to provide free consultations. A positive trend is now being observed – indicators are beginning to stabilize as people try to return to their normal lives and continue taking care of their health.

The functioningof the medical system was also affected by the fact that not only patients but also doctors moved to other regions or went abroad due to the war.Primarily, this led to the redistribution of specialists within the country, with a large number of internally displaced medical workers finding jobs in other cities [3].Ihor Kuzin, the Chief Sanitary Doctor of Ukraine, has stated that one of the main problems amid the destruction is the limited and unequal access to medical care. To address this issue, mobile brigades have been created to serve hard-to-reach areas, medical staff rotations are conducted, and formal barriers are reduced (for example, family doctors now may have more patients than originally planned) [8].

The results of a sociological survey conducted by the Razumkov Center's sociological service from February 22 to March 1, 2023, as part of the MATRA Program project, identifiedthe main medical issues Ukrainians faced during the war. Almost 22% of respondents believed that the state of domestic healthcare had worsened since the start of the war. The most widespread problem was the significant increase in the cost of essential medicines, which 53% of Ukrainians reported. Additionally, 26% were unable to buy necessary medications due to their unavailability, while 25% noted that air raid alerts and power outages disruptedtheir treatment.Another 18% of respondents mentioned that doctor appointments or surgeries were canceled due to air raid alerts or power outages. 15% complained about the inability to contact a doctor or call an ambulance due to communication issues. 12% could not receive certain medical services because of military actions or martial law, and 9.5% encountered cases where the doctor they needed had either gone abroad or relocated to another region [9].

One of the most critical problems at the beginning of the full-scale invasion was the lack of fully equipped bomb shelters in medical institutions. In the early days, doctors had to work in field conditions, performing medical procedures not in sterile operating rooms but

in basements and storage rooms. Now, many hospitals have shelters equipped to allow emergency surgical interventions when necessary.Today, medical institutions continue to perform the most urgent emergency surgeries, while planned transplants and blood donation services remain active. Additionally, the war has accelerated the introduction of new approaches to treatment.

The most vulnerable remain people living in temporarily occupied territories and in zones of active hostilities. In addition to limited access to medical care, theirproblems are compounded by the fear of being shot at, poortransport accessibility, and an insufficient number of doctors.In response, online services providing medical assistance to Ukrainians, including on a volunteer basis, have begun to emerge. Primarily, this refers to telemedicine:the ability to receive consultations from doctors via chat, phone, or video call. Telemedicine allows consultations and diagnostics even in combat zones, where access to medical facilities may be limited or dangerous [3].

Currently, all medical institutions in Ukraine operate within an electronic healthcare system. The development of eHealth and IT improvements in the medical field, as well as the transition to a modern level of service, are ongoing. The war and mass displacement of people have become a driving force for innovation in the medical sector. The reform of outdated industry standards has become a necessity, accelerating the adoption of information technologies and electronic medical assistance.

Yulia Vitrova, medical director of a network of healthcare facilities, states that the priorities include resilience; humanism and the expansion of patient rights; cross-border service provision; and the creation of an attractive environment for medical professionals. These steps may not only address urgent problems in the sector but also lay the groundwork for improving access to medical services, providing urgent care for war victims, and transforming the healthcare system by expanding its core services.

WAYS TO PRESERVE THE RESOURCES OF HEALTHCARE PROFESSIONALS

Ensuring an attractive environment for medical workers is an important aspect of developing the healthcare sector during wartime and internal population migration. Healthcare workers are the most valuable resource inthe system. The key aspects that can contribute to supporting theminclude:

- Safety: during war and conflict, it is necessary to develop effective safety systems to protect medical workers, provide them with essential equipment, and train them in safety measures.
- Financial motivation: a decent salary and financial incentives can make the medical profession more attractive. This includes increasing salaries, providing additional bonuses for working in combat conditions, and offering financial support for education and professional development.
- Professional development: ensuring opportunities for professional growth and continuous education makes a medical career more appealing. This includes participation in internships, workshops, seminars, training sessions, and conferences.
- Psychological support: working in a war zone can lead to high stress levels for medical workers. Psychological support and counseling can help them cope with mental health challenges.
- Improvement of working conditions: modern equipment and improvements in workplace conditions in medical institutions can enhance the comfort of medical workers and make their work less exhausting.

Comfortable working conditions will help attract and retain qualified personnel, ensuring access to quality medical care for the population. One of the key current challenges is ensuring a sufficient number of medical workers [10].

MEDICAL GUARANTEES PROGRAM

The Medical Guarantees Program (MGP) not only continues to operate during the war but also introduces new service packages. The Medical Guarantees Program – 2025 covers all primary types of medical care for adults and children, including primary, specialized, and highly specialized care, emergency and palliative care, medical rehabilitation, as well as care during pregnancy and childbirth. In total, MGP-2025 includes 44 service packages [11].

The government has approved the implementation procedure for the MGP in 2025, allocating over 175.5 billion UAH, which is more than 16 billion UAH above the previous year's amount. The document defines the list of medical services covered by the state, tariffs, cost calculation rules, as well as the list of medicines and medical devices that patients can receive through the reimbursement program. More than 25 billion UAH is allocated for medical services related to primary health care, nearly 11 billion UAH for emergency medical assistance, and over 122 billion UAH for specialized and palliative care, including more than6 billion UAH for medical rehabilitation.

Starting in 2025, all public and specialized healthcare facilities will become part of a unified medical space within MGP, improving accessibility and service quality. For the first time, the MGP will also finance expert teams assessing individuals' daily functioning, who will be deployedto medical institutions from January 1, 2025, as part of the medical-social examination reform.

The "Affordable Medicines" reimbursement program was significantly expanded in 2025 – more than 30 new active substances were added, including combined drugs for the treatment of cardiovascular diseases, rheumatological, neurological, endocrinological and pediatric diseases. Medical guarantees also provide for new tariffs for palliative care and the expansion of rehabilitation services. Also, from January 1, 2025, free mental health services will be provided by all primary health care institutions (regardless of ownership) contracted by the National Health Service of Ukraine (NHSU) to provide primary health care [12].

MILITARY MEDICINE AND REHABILITATION CENTERS

On July 27, 2024, the first annual International Medical Congress on Military Medicine and Mental Health was held. The event addressed issues related to the medical support of Ukraine's Armed Forces, mental health, and the reintegration of military personnel released from captivity. Ukraine's Minister of Defense, Rustem Umerov, stated that military personnel werenow equipped with medical kits and tourniquets, and the volume of pre-hospital care supplies had been approved. Based on this, modern training programs are being implemented, rehabilitation centers are being developed, and the process of decommissioning medical supplies in military units has been simplified. Digitalization in medicine is also being advanced, with new conditions established for digital healthcare and psychological support management. Additionally, cooperation with international partners will result in the creation of a specialized laboratory for quality control of medical supplies. A coordination center for managing medical resources has already started operating.One of the priorities for the coming years is the establishment of an effective rehabilitation system for military personnel, enabling them to return to service after injuries. In collaboration with NATO, Ukraine is completing the construction of five "Renovator" centers – modern rehabilitation facilities for military personnel, where the latest technologies will be implemented, and specialists will provide high-quality treatment and rehabilitation [13].

As mentioned earlier, the expansion of rehabilitation services within the healthcare system is ongoing. This includes the establishment of rehabilitation departments in cluster and supra-cluster hospitals across the country, as well as specialized national-level institutions. The rehabilitation process for both military personnel and civilians requiring medical assistance begins as early as possible. If an injury, wound, or household trauma results in functional limitations, rehabilitation specialists engage with the patient immediately after stabilization.

Patients can choose from among the medical institutions contracted by the National Health Service of Ukraine (NHSU) under one of two packages: "Rehabilitation Assistance for Adults and Children in Inpatient Settings" or "Rehabilitation Assistance for Adults and Children in Outpatient Settings." Additionally, under the "Medical Rehabilitation of Infants Born Sick or Premature" package, rehabilitation services are available for infants during their first three years of life, with 129 medical institutions currently providing such care.

Evidence-based rehabilitation is a complex process that involvesphysical and, wherenecessary, psychological interventions to help patients adapt more quickly to new conditions, restore functionality, and minimize the impact of their injuries on daily life. These services are provided free of charge [14, 15].

The medical network has established a rehabilitation system for the wounded and is significantly expanding its capacity. According to Ukraine's Minister of Health, Viktor Liashko, at the beginning of the war, the system could deliver only 2,000 rehabilitation sessions for the wounded per day, but now it has been scaled up to accommodate 10,000 sessions daily.

A major challenge for the national healthcare system is the high demand for prosthetics. Prosthetics for all those in need in Ukraine are provided free of charge and funded by the state budget. The general program covers elderly individuals, persons with disabilities, children, military personnel, and civilians affected by military aggression. For military personnel, the program ensures timely access to prosthetics, while for other categories, it covers the production, maintenance, repair, and lifetime replacement of prosthetic devices. Additionally, there is a separate program for the military that provides advanced prosthetic solutions, known as bionic prostheses [16].

The growing number of patients with chronic pain syndrome due to war-related injuries has become one of the key challenges for Ukraine's healthcare system. This issue affects both military personnel and civilians. Many of thesepatients suffer from pain following mine-blast injuries, amputations, and neuropathic damage. Uncontrolled pain complicates rehabilitation, prosthetic adaptation, and social reintegration, while also increasing the risk of opioid dependence. It leads to higher medical costs and worsens patients' mental health, triggering psychological disorders such as post-traumatic stress disorder (PTSD) and depression.Timely and effective treatment of acute pain reduces the risk of its transition to chronic pain, facilitates faster rehabilitation, lowers the risk of psychological disorders and opioid dependence, and improves patients' overall well-being. To support military personnel and civilians in returning to full lives after war-related injuries, the Ukrainian Ministry of Health is working to establish centers dedicated to diagnosing and treating acute and chronic pain. For instance, training has begun at the "Feofaniya" Clinical Hospital for medical professionals who will work in such centers invarious cities across Ukraine. The pain management program includes three key stages, based on the U.S. experience: pre-hospital care, hospital treatment, and rehabilitation. This comprehensive approach allows for the most effective care for patients suffering from chronic pain syndrome [17].

INTERNATIONAL SOLIDARITY AND ASSISTANCE

More than 30 European countries have offered their assistance to Ukraine in treating wounded individuals and patients with oncological diseases. War-affected Ukrainians are evacuated for free treatment abroad under the medical evacuation program Medevac, which is an essential component of support for Ukrainians impactedby the war. This program allows Ukrainian citizens to receive specialized treatment free of charge in leading European clinics, while simultaneously reducing the burden on Ukraine's healthcare system. Medical evacuations are conducted almost daily in cooperation with the Ministry of Health of Ukraine, the European Commission, the WHO, and other international partners. Patients transported to foreign clinics include both children and adults

affected by shelling, patients with neonatal conditions, rare diseases, and war-related injuries. Priority is given to individuals who require emergency treatment for injuries sustained due to shelling, wounds, and complications from such conditions.In total, over 5,700 Ukrainians have been evacuated through this program, including patients with mine-blast injuries, those in need of prosthetics, and cancer patients. Among the evacuees are approximately 750 children with oncological diseases. A physiciandetermines whether a patient qualifies for treatment abroad and prepares the necessary documentation [18].

On September 12, 2024, Ukraine's Minister of Health Viktor Liashko, Director of the WHO European Regional Office Dr. Hans Kluge, and Head of the WHO Country Office in Ukraine Jarno Habicht held a meeting to discuss key areas of cooperation aimed at strengthening the resilience of Ukraine's healthcare system during the war, continuing healthcare reforms, and advancing the recovery of the medical sector.

During the meeting, they discussed ways to enhance cooperation in the following areas:emergency response to urgent medical needs in the most war-affected regions (provision of emergency medical aid, medical evacuations, rehabilitation, delivery of essential medical equipment and medications, etc.);improvement of emergency medical care (training personnel, ensuring coordination of services at all levels, implementing monitoring systems, and introducing new medical standards);combatting infectious diseases (vaccination, eradication of polio, measles, and rubella, as well as ensuring patient safety and infection prevention in hospitals);mental health and rehabilitation (development of a comprehensive mental health system, including both medical care and psychological support for individualsaffected by the war); international coordination and partnerships of Ukraine with other countries and organizations, providing access to advanced technologies, exchange of experience and knowledge [19].

MENTAL HEALTH: CHALLENGES OF TODAY

According to WHO data, about 10 million people in Ukraine are at risk of mental disorders. As a result of the war, people face death and illness, the loss of their homes, and separation from loved ones. Practically the entire population of Ukraine lives under constant stress, experiencing anxiety for their own lives and the safetyof their families. This chronic insecurity undoubtedly has a negative impact on mental health. Participation in combat or being in frontline areas with constant missile and artillery shelling, bomb attacks, or occupation significantly increases vulnerability to psychosocial stress, contributing to a growing incidence of mental disorders such as depression, anxiety, and post-traumatic stress disorders (PTSD).

The same consequences can be caused bythe loss of a sense of security; increased vulnerability in regions targeted by missile attacks;the constant threat of drone strikes; displacement to other regions of the country and, as a result, job loss and the destruction of familiar, comfortable environments; household difficulties; financial hardships;social isolation;uncertainty about the future and, again, anxiety for the safety of loved ones [20].

The Ministry of Health of Ukraine (MOH) predicts that, due to the war, over 15 million Ukrainians will require psychological support, with about 3–4 million needing pharmacologicaltreatment. After the war, at least one in five people will experience negative mental health consequences.According to MOH data, 20–30% of people who have experienced traumatic events may develop PTSD. Additionally, in the next 5–7 years, an increase in the number of people suffering from drug, alcohol, and other addictions is expected. Due to the psychological strain caused by the war, Ukrainians will age 10–15 years faster, experiencing diseases typical of middle and old age at least a decade earlier than usual [21, 22]. Therefore, mental health support during the war in Ukraine is extremely important.

In 2022, on the initiative of First Lady Olena Zelenska, with the support of WHO, the National Program for Mental Health and Psychosocial Support was launched to build an effective system of high-quality and accessible mental health services so that everyone in need could use them.

Throughout 2022–2023, the Ministry of Health of Ukraine, together with relevant departments, ensured access to mental health services at the primary level, through family doctors, therapists, and pediatricians. To achieve this, Ukrainian medical professionals were trained under the WHO's global Mental Health Gap Action Programme (mhGAP) to increase access to mental health care by involving primary care doctors in assisting individualswith mental disorders.As of mid-2024, more than 96,000 participants have received certificates for completing mhGAP training, including nearly 19,000 primary care doctors.

In November 2022, a new service package, "Support and Treatment of Adults and Children with Mental Disorders at the Primary Level of Medical Care," was added to the Medical Guarantees Program. By early summer 2024, more than 1,000 medical institutions had signed contracts with the National Health Service of Ukraine (NHSU) for this MGPpackage. Information about these institutions is available on the electronic map of medical service providers under the category "Psychological and Psychiatric Assistance," which contains data on doctors who provide free psychological and psychiatric care to patients in medical facilities that have a corresponding contract with the NHSU.

The next stage involves setting up a referral system to specialized professionals and developing outpatient services for psychological care. In 2024, the establishment of mental health centers began, based on cluster and general hospitals, as along with the opening of separate psychological rehabilitation centers.

Additionally, the integration of mental health support services into the emergency medical care system is

planned. The option of providing psychiatric assistance at the patient's location by mobile multidisciplinary teams is also being developed.

The issue of mental health support for military personnel is of critical importance. After their first deployment to a combat zone, symptoms of depression, anxiety, or acute stress reactions to combat stress or trauma may appear, along with depressive responsesand generalized anxiety disorder. Many servicemen, due to the high risk of developing PTSD, require assistance from psychologists, psychiatrists, and psychotherapists. At the same time, it can be stated that the Ukrainian Armed Forces are insufficiently staffed with psychologists.

Mental health specialists also provide psychosocial support and assistance to the families of military personnel. In combat military units, stress control units operate at the brigade level, where psychiatrists, psychologists, social workers, mental health specialists, occupational therapists, and nurses work. These professionals identify soldiers with signs of PTSD, organize preventive and recovery measures, and promptly provide short-term rehabilitation for manifestations of combat stress at field recovery centers near the primary deployment sites of military units.

Mental health professionals also provide psychosocial support and accompany the families of military personnel. In combat military units, stress control divisions operate at the brigade level, where psychiatrists, psychologists, social workers, mental health specialists, occupational therapists, and nurses work. They identify soldiers with signs of PTSD, organize preventive and recovery measures, and ensure short-term timely rehabilitation in cases of combat stress at a field recovery center near the main deployment site of military units.

Key areas of work for mental health protection units for military personnel include developing soldiers' psychological resilience to combat stress, readiness for action in rapidly changing conditions, and coping with prolonged psychological strain. They train service members in techniques of psychological self-regulation in combat conditions, the ability to replace irrational thoughts with constructive ones, and the development of self-control skills and mastery of effectiveactions in extreme situations. Other essential aspects involve fostering confidence, concentration, and attention management skills – the ability to focus on the necessary object, remain present in the moment, instantly assess the incoming information flow, identifycritical success factors, concentrate on them, and act accordingly. Additionally, soldiers are trained to counteract involuntary attention fixation and its dispersion, ensuring optimal decision-making in critical situations [20].

PROSPECTS

The Minister of Health, Viktor Liashko, stated at the final meeting of the Congress of Local and Regional Authorities under the President of Ukraine in Lviv on December 17, 2024, that in 2025, more than 175.5 billion UAH will be allocated from the state budget to finance the Medical Guarantees Program. Additionally, a subsidy of 1.3 billion UAH will be directed to local budgets for the functioning of blood services and children's homes.

Among the key changes in the medical sector for the next year are the creation of a unified medical space by integrating all public healthcare institutions into the MGP, ensuring the free provision of services for patients, expanding the reimbursement program "Affordable Medicines," and fully meeting the need for donor blood and its components.The Ministry of Health (MOH) also continues to equip hospitals with expensive medical equipment.

Another significant step in 2024 was the ratification by the Verkhovna Rada of Ukraine of framework agreements on official support for the project to establish modular hospitals in Ukraine and for the modernization of breast cancer diagnosis and treatment. Two framework agreements on strengthening cooperation were signed by the governments of Ukraine and France during the International Ukraine Recovery Conference (URC2024) in Berlin.

Another priority in the healthcare sector is the restoration and reconstruction of Ukraine's medical infrastructure. Despite the challenges and difficult conditions, the MOH of Ukraine and its partners are making maximum efforts to ensure that Ukrainians have access to essential medical services. One of the initiatives is the digital system DREAM, which provides a unified digital route and space for all reconstruction and recovery projects, ensuring their transparency and effective implementation at national, regional, and local levels.

As part of one of the joint projects between the MOH and the World Bank, "Strengthening the Healthcare System and Preserving Lives" (Heal Ukraine), 2.7 billion UAH has been planned for infrastructure restoration and reconstruction projects. Support for energy efficiency measures in medical facilities is also ongoing.

Additionally, within the framework of the HEAL Ukraine project, 124.5 million UAH has been allocated for the construction of 60 psychological entertainment spaces in primary healthcare centers to bring mental health services closer to communities [24, 25].

MEDICAL EXPERTISE REFORM

A large-scale reform of medical expertise began on January 1, 2025. The outdated approach to assessing medical and social losses has been replaced by a modern evaluation of daily functioning. For individuals, the process of obtaining disability status has been significantly simplified, as most procedures have been streamlined and digitized [15]. The reform replaces the outdated Medical and Social Expert Commission (MSEC) system with a transparent, human-centered model. Decisions will be made considering the individual needs of each person and in a transparent and fair manner, thanks to process digitization.

By order of military administration leaders and in coordination with the Ministry of Health, a list of hospitals has been designated where expert teams will assess individuals' daily functioning. Currently, this list includes 286

healthcare institutions that meet modern standards of medical service quality and cover all regions of the country. At these hospitals, expert teams conduct professional assessments of daily functioning and determine limitations in life activities [26, 27].

DISCUSSION

One of the priority areas in the healthcare sector is the restoration and reconstruction of Ukraine's medical infrastructure. Continuous shelling and bombings, destruction of medical facilities, a shortage of medical specialists, disruptions in logistics, and the displacement of a large number of citizens have all become obstacles to the timely and adequate provision of medical resources to the population.

Amid the full-scale war in Ukraine and significant damage, the healthcare system has endured and continues to develop. One indication of this is ongoing healthcare reform, which effectively helps to transform Ukraine's healthcare system.

The implementation of people-centered principles in healthcare is also a requirement of the times to respond to the growing demand for medical services acrossthe entire population.

The process of building a rehabilitation assistance system for civilians and military personnel, in accordance with the principlesof evidence-based medicine, is ongoing.

Supporting mental health during the war in Ukraine is extremely important, as practically the entire population of the country lives in constant stress, experiences anxiety for their own lives and the lives of their loved ones, and lacks a sense of safety.

An important direction is ensuring easy access to medical services. War and the mass displacement of people have become a driving force for innovation in the medical sector. State-level support for the implementation of new technologies and convenient tools in the field of medical IT technologies is essential. Telemedicine in Ukraine is still developing but has great potential for improving both access to and quality of medical care, especially under martial law and internal migration conditions.

Enhancing cooperation with other countries and organizations is extremely relevant to ensure access to advanced technologies, exchange experience and knowledge with partners on emergency medical response, improve emergency medical care, and ensure mental health and rehabilitation for those inneed.

CONCLUSIONS

1. Despite the ongoing full-scale war in Ukraine, rapid restoration and high-quality reconstruction of medical infrastructure continue. Ukraine's healthcare system functions, adapts, and – despite everything – responds clearly to the needs and challenges of its citizens.
2. One of the most pressing issues has been the lack of fully equipped bomb shelters in medical facilities. Many hospitals now have shelters where, in emergency cases, doctors can even perform surgical interventions.
3. Almost the entirepopulation of Ukraine lives in constant stress, experiencing anxiety for their own lives and the lives of their loved ones, and not feeling safe – factors that collectively have a negative impact on mental health.
4. An important aspect of the development of the medical sector during the war and internal migration of the population is ensuring an attractive environment for medical professionals, the most valuable resource of the system.
5. In cooperation with NATO, Ukraine has completed the establishment of five "Renovator" centers – modern rehabilitation facilitiesfor military personnel that will implement advanced technologies, ensuring high-quality treatment and rehabilitation for service members.
6. International solidarity with the people of Ukraine and the expansion of international cooperation are priority areas for maintaining the resilience of Ukraine's healthcare system during wartime.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

Virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies in the training of paramedics today and tomorrow – in the aspect of the future of education in medical rescue

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ABSTRACT

The integration of virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies into paramedic training is a rapidly evolving trend that offers significant advancements in medical education. These technologies, originally developed for fields like military and entertainment, are now providing innovative solutions in the medical rescue sector. VR, AR, and MR enable the creation of immersive, interactive learning environments that simulate realistic, high-stress medical scenarios without putting patients at risk. VR allows paramedics to engage in controlled, repetitive training scenarios that build confidence and skill. AR, on the other hand, provides real-time, context-sensitive information that can aid paramedics during live medical procedures, while MR combines both technologies to offer even more dynamic, real-time interaction with both real and virtual elements. These tools significantly improve the effectiveness and safety of training by offering the opportunity to practice in diverse, challenging conditions such as natural disasters or mass casualty incidents. However, the adoption of VR, AR, and MR in paramedic education faces challenges, including high costs and the need for specialized training. Despite these barriers, the potential for these technologies to revolutionize paramedic training is immense. As they become more accessible, VR, AR, and MR will play a crucial role in shaping the future of medical education, enhancing both the quality of care provided and the efficiency of rescue operations.

KEY WORDS

virtual reality (VR), augmented reality (AR), mixed reality (MR), paramedics, training of paramedics

INTRODUCTION

In today's world, medicine and rescue are constantly evolving, and technological progress is becoming a key element in improving the quality of comprehensive patient care. One of the most promising directions in the education of paramedics is the use of advanced technologies, such as virtual reality (VR), augmented reality (AR) and mixed reality (MR) [1-20]. Technologies that were once used in various areas, such as the military industry, entertainment or the world of computer games, which were originally aimed at streamlining activities in these specific fields, today have found wide and diverse applications in many other industries. One example is their use in medical education, where innovative technologies, such as computer simulations, virtual reality or advanced data analysis systems, support the learning and development of medical personnel's skills [1-3, 5, 8, 11, 14-19].

Paramedic training is a process that requires a high level of precision, practical skills and quick decision-making in difficult conditions, where stress, uncertainty and lack of time prevail [3-7,10-13, 16, 18, 19]. Traditional teaching methods, although still invaluable, have their limitations, e.g. simulations in real conditions, although valuable, are expensive, time-consuming and can be dangerous [1, 2, 6, 12, 13, 15, 19, 20]. VR, AR and MR technologies offer innovative alternatives that enable the creation of realistic, interactive learning environments, allowing for the simulation of medical situations without risk to patients and with minimal operational costs. Moreover, they allow for the repetition of exercises, personalization of scenarios and quick access to a variety of rescue scenarios [1-13, 16, 18, 19].

AIM

The aim of this review article is to present the current applications of virtual (VR), augmented (AR) and mixed (MR) technologies in the training of paramedics, taking into account their impact on the quality and effectiveness of education in this field. The article aims to identify the main benefits of integrating these innovative technolo-

gies with traditional teaching methods, as well as to discuss the challenges related to their implementation in the training process.

MATERIALS AND METHODS

To achieve the aim of this review, the literature analysis will focus on studies on the role of VR, AR and MR technologies in the training of paramedics, especially in the context of the future of education in emergency medical services. A review of available scientific publications will be conducted, including clinical trials, systematic reviews and meta-analyses, with particular emphasis on issues related to the organization of training, the use of technology in rescue simulations and best practices used in the education process of paramedics. 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 qualitative analysis of published materials, taking into account the research methodology, results and conclusions, which will allow for the assessment of the strengths and weaknesses of previous studies.

REVIEW AND DISCUSSION

VIRTUAL REALITY

Virtual reality (VR) is a computer technology that creates interactive, three-dimensional environments in which users can immerse themselves and interact with the virtual world using special devices such as VR goggles (their task is to display images in 3D), headphones (responsible for emitting sounds), or controllers (they enable the transfer of human movements to the virtual world) [1, 2, 4, 8-15, 18, 20]. VR simulates real or fictional scenarios, allowing the user to experience them in a way that engages sight, hearing, and sometimes touch, which gives the impression of being "drawn" into a virtual space [1-3, 8, 12, 15]. Unlike traditional media, VR offers full immersion, which makes the user feel like a part of the digitally generated environment, making it an effective tool in education, simulations, and training [1-4, 8, 10-12, 15].

VIRTUAL REALITY (VR) IN PARAMEDIC TRAINING

Virtual reality (VR) is becoming increasingly popular as a tool in paramedic training, offering an innovative approach to education. It brings a number of benefits that significantly improve the quality of education and preparation for work in extreme conditions [3, 4, 9-13, 15, 16, 18, 19]. First of all, VR enables the creation of realistic, interactive medical scenarios that can be repeated many times, enabling the creation of realistic, interactive learning environments [1-3, 8, 10-15, 18, 19]. Such simulations help paramedics build self-confidence and the ability to make quick decisions in crisis situations. In addition, VR allows training to be conducted in various, often difficult to recreate, conditions, such as mass casualties or natural disasters, without endangering the health and safety of patients or participants [3, 4, 10-14, 16, 18, 19]. Another advantage is the possibility of personalizing scenarios, which allows the level of difficulty to be adjusted to the individual needs and skills of rescuers, which in turn promotes a more effective learning process [1-4, 10, 12, 16, 18, 19]. VR technologies also offer easy access to advanced medical tools and devices, the use of which in real-world training conditions could be costly or logistically challenging. Thanks to this, rescuers have the opportunity to learn how to use modern equipment in realistic conditions, which translates into better preparation for work in the field [3, 4, 10, 12-16, 18, 19].

AUGMENTED REALITY

Augmented reality (AR) is a technology that combines virtual elements with the real world, allowing the user to interact with digital objects that are superimposed on the image of the real environment [1, 5-7, 9, 13, 20]. Unlike virtual reality (VR), which creates a completely virtual environment, AR enriches the real world with additional information, such as images, sounds or data that are displayed on the screen of a device, e.g. a smartphone, tablet, AR glasses [5,6]. Thanks to AR, the user can interact with these virtual elements that are integrated with the real world, which makes this technology particularly useful in education, medicine, navigation or entertainment. In the context of training, AR allows for the delivery of additional information and instructions in real time, which supports the learning process and enhances the effectiveness of practical training [5, 6, 13].

AUGMENTED REALITY (AR) IN PARAMEDIC TRAINING

Augmented reality (AR) is becoming an increasingly popular tool in paramedic training, offering new opportunities for practical education and interaction with the real environment [3, 5, 6, 13]. Thanks to AR, paramedics can use real medical tools and equipment, while receiving additional information on the device screens – such as tips, instructions or data on the patient's condition. This type of real-time support can significantly improve the speed of decision-making, as well as the accuracy of medical procedures [3, 5, 6]. AR also allows for simulating various scenarios in real conditions, where virtual elements, such as virtual patients, are superimposed on the real environment, allowing for realistic exercises in familiar spaces such as ambulances, hospitals or accident sites [3, 5, 6, 13]. In addition, AR supports the individualization of the teaching process, adapting the level of difficulty and type of information to the paramedic's skills, which enables effective and efficient training at every stage of the career [3, 5, 6]. AR technologies in the training of paramedics are becoming an invaluable tool that supports both learning and improving skills in dynamic, changing rescue conditions [3, 5, 6, 13].

MIXED REALITY (MR)

Mixed reality (MR) is a technology that combines elements of virtual reality (VR) and augmented reality (AR), enabling interaction with both real and virtual objects in

real time [3, 4, 9, 10, 15, 17, 20]. In MR, virtual objects can be placed in the real world and react to real elements of the environment, which creates a dynamic and interactive environment [3, 4, 10, 15, 17, 20]. Unlike AR, which only superimposes virtual elements on reality, MR allows for more advanced interaction, where virtual objects can interact with real objects, e.g. change depending on the environment they are in [3, 15, 17]. MR technology is used in various fields, such as education, medicine, engineering and entertainment, because it allows for the creation of advanced, immersive experiences that combine the physical and virtual worlds in a more fluid and realistic way [3, 15].

MIXED REALITY (MR) IN PARAMEDIC TRAINING

Mixed reality (MR) in paramedic training combines the advantages of virtual and augmented reality, creating an advanced, interactive environment that allows for full integration of virtual and real elements in real time [3, 4, 9, 10, 15, 17]. In MR, paramedics can use real medical tools and equipment, while also having access to virtual instructions, information about the patient's condition or simulated scenarios. This type of technology enables the creation of realistic simulations that engage participants' senses while allowing them to interact with both virtual and real elements [3, 4, 9, 15]. An example would be the simulation of a medical incident in a real space, where virtual patients, virtual assistants or changing crisis conditions can affect the rescuer's actions [3, 4, 9, 10, 15]. MRI enables the creation of complex scenarios that accurately reflect the conditions that paramedics may encounter in real life, while offering full flexibility in terms of personalizing and adapting training [3, 4, 9, 10]. MRI technology in the training of paramedics therefore enables the improvement of both technical skills and the ability to make decisions in changing, often stressful conditions, which significantly improves the quality of education in this field [3, 4, 9, 10, 15].

TODAY AND TOMORROW: CHALLENGES AND PERSPECTIVES OF TECHNOLOGIES IN PARAMEDIC TRAINING

Technologies such as virtual reality (VR), augmented reality (AR) and mixed reality (MR) are gaining importance in the education of paramedics, but their implementation is associated with both enormous potential and a number of challenges [1-3, 6, 16, 17]. Modern training based on these technologies offers great benefits, such as improved learning efficiency, safety of exercises and the possibility of repeating scenarios [1-4, 6, 9, 16, 18]. However, although many educational institutions are already implementing innovative technologies, their full use in paramedic training encounters several key difficulties [1-3, 6].

One of the main challenges is the cost of implementing and maintaining these technologies. Advanced VR, AR or MR systems require significant investments, both in equipment and in the development of appropriate educational programs [1-3, 6]. Additionally, training of personnel who operate these technologies is another element difficult to implement, especially in countries with limited financial resources [6, 14]. Another barrier is too low a level of immersion, which can limit the realism of scenarios and affect the effectiveness of training [9]. Nevertheless, the prospects for the development of these technologies in rescue education are promising. As technology becomes more and more accessible, this form of education will gain popularity, offering increasingly advanced simulations that reproduce difficult real-life conditions in a way that is impossible to achieve with traditional methods [1-4, 6, 14, 18]. In the future, VR, AR and MR technologies may become a key tool in the preparation of paramedics, allowing them to gain experience in realistic but safe conditions, which significantly improves the quality of patient care and the effectiveness of rescue operations [1-4, 6, 14, 19].

CONCLUSIONS

Modern technologies such as virtual reality (VR), augmented reality (AR) and mixed reality (MR) are becoming an important tool in medical education, offering innovative and effective solutions that improve the quality of training, enabling the creation of realistic, interactive emergency scenarios. Thanks to VR, AR and MR, paramedics have the opportunity to train in controlled but realistic conditions, which allows them to improve their skills in difficult, stressful situations, without risk to patients. At the same time, these technologies enable repeatability of exercises, personalization of scenarios and quick access to a variety of situations, which promotes a more effective educational process.

However, fully implementing these technologies in paramedic training presents challenges, such as the high costs of setting up and maintaining VR, AR, and MR systems and the need to integrate new tools with traditional teaching methods. Nevertheless, the prospects for the development of technology in this field are promising. Over time, as technologies become more accessible, their role in paramedic education will grow, offering new opportunities to improve skills and prepare professionals to work in difficult, real-world conditions. These technologies have the potential to revolutionize paramedic education, improving the quality of medical care and the effectiveness of rescue operations, which in the future may contribute to saving many lives.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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REVIEW ARTICLE

Opportunities and challenges of nasal medications in emergency care: a literature review

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ABSTRACT

Aim: This study aims to explore the clinical utility of intranasal medications in emergency care, with a comparison to other administration routes.

Material and Methods: A search of PubMed on March 12, 2025, retrieving 55 articles from 2020-2025. Studies published in English between 2020 and 2025, along with select relevant publications from earlier years, were included. Ultimately, 38 articles met our inclusion criteria. All authors reviewed and revised the final manuscript.

Intranasal therapies are quick, easy to use, and effective in emergencies like pain, seizures, and overdoses. Analgesics such as fentanyl, ketamine, and sufentanil show efficacy comparable to intravenous opioids. Intranasal naloxone and nalmefene improve access in overdose emergencies, while nasal midazolam and diazepam are effective and well-tolerated for seizure control. FMXIN002 demonstrates potential for anaphylaxis treatment. Despite advances in the use of intranasal drugs, challenges remain. Continued innovation may lead to entirely new therapeutic possibilities.

Conclusions: Intranasal drug administration is increasingly recognized as a practical and non-invasive alternative method, particularly in scenarios requiring rapid therapeutic action. This route is especially advantageous in pediatric populations due to ease of use and patient compliance.

KEY WORDS

intranasal, drugs, emergency medicine, prehospital care

INTRODUCTION

Intranasal drug administration has gained increasing attention in emergency medicine. This is primarily because it allows for quick and easy drug delivery, with effects appearing shortly after administration [1, 2]. It provides a non-invasive alternative for delivering essential drugs, especially when the intravenous or intramuscular routes are limited or not feasible. What is more, intranasal medications can be successfully delivered regardless of a patient's body type, cooperation, or age [3, 4]. In certain cases, this method of administration may be limited, for example in patients with facial trauma, epistaxis or white mucus [1, 2]. The purpose of this review is to explore the applications, benefits, and limitations of various intranasal medications in emergency medicine.

AIM

This study aims to explore the clinical utility of intranasal medications in emergency medicine. The research includes a comparative analysis of these drugs when administered intranasally versus alternative routes.

MATERIAL AND METHODS

This study drew on materials identified through open-access database PubMed. A literature search was carried out on March 12, 2025, using the terms (emergency medicine) AND (intranasal) AND (drugs), covering the years 2020 to 2025 and resulting in 55 relevant articles. Additional references were sourced by screening the bibliographies of selected studies, allowing for the inclusion of some pre-2020 papers. We included studies published in English that fell into categories such as original research, reviews, systematic reviews, case reports, or observational studies. Ultimately, 38 articles met our inclusion criteria. All authors reviewed, discussed, and revised the final version of the review to ensure its accuracy and clarity.

REVIEW

INTRANASAL MEDICATIONS IN PAIN MANAGEMENT

Fentanyl

Fentanyl is a commonly used opioid for pain management in patients in hospital emergency departments. Fentanyl can be administered through different routes. While intravenous administration is the most common, other methods may be used in specific conditions [5]. The intranasal (IN) method has become more popular due to its safety, simplicity, and non-invasive approach. Because the nasal mucosa is densely vascularized and full of capillaries, drugs are rapidly absorbed, leading to a quick onset of analgesia. It also eliminates the necessity for a peripheral catheter [1, 2].

Nazemian et al. compared the analgesic efficacy of two methods of fentanyl administration (i.e., intravenous and intranasal) in patients with severe renal colic pain.

They found that while intranasal fentanyl effectively controlled pain, it was significantly less effective than intravenous fentanyl. This option may be considered in cases where obtaining intravenous access could cause a delay in pain management, such as in crowded emergency departments. Moreover, another goal of Nazemian et al. study was to assess patient satisfaction between those who received fentanyl through the intravenous or intranasal routes. They observed a higher level of satisfaction in patients who received the drug intranasally, but this difference was not statistically significant compared to those who received intravenous fentanyl [5].

Lindbeck et al. in their study recommend the use of intranasal fentanyl as an alternative to intramuscular or intravenous opioids in pediatric patients. It is advised when pain management is needed before obtaining intravenous access or when intravenous access is not available. There were no significant differences in pain severity at 5, 10, 15, 20, 25, and 30 minutes after intranasal fentanyl was administered when compared to intramuscular or intravenous opioids, and no clinically meaningful differences in side effects between the two methods of administration. Fentanyl, when used with a non-invasive administration route, offers a significant chance to improve pain management in pediatric patients in the prehospital environment [6].

Fentanyl is one of the drugs used to manage breakthrough pain (BTP) in cancer patients. Due to its rapid onset, prolonged effect, and strong analgesic properties, intranasal fentanyl can be considered as one of the effective treatments for BTP [7, 8].

In studies conducted by Nardi-Hiebl S. et al., the bioavailability and pharmacokinetic profiles of fentanyl were compared across three different administration routes: intranasal, transmucosal, and intravenous. Fentanyl administered intranasally reached peak concentrations more quickly than when administered transmucosally, although it still took more than three times longer to reach maximum concentration compared to the intravenous product. This study indicates and confirms that intranasal administration is generally beneficial for quick relief of acute pain [9].

Ketamine

Ketamine is a drug with analgesic and anxiolytic effects. It does not cause the release of histamine into the body, which may occur with the administration of opioids. However, it can cause side effects such as: dizziness, impaired taste, increased drowsiness, tachycardia and hypertension [10]. The most important contraindication to its use are cardiac diseases [1]. Ketamine has many routes of administration: intravenous, intramuscular, oral, sublingual, rectal, but it can also be administered intranasally. When administered intranasally, it can be safely combined with dexmedetomidine, obtaining a good sedative effect. On the other hand, the combination of ketamine with sufentanil allows for a rapid analgesic effect with a low risk of side effects [10]. Thanks to the quick and easy intranasal route of ketamine administration, it is possible to reduce the patient's suffering in emergencies, without delaying the start of pain treatment [1].

Savari et al. in their study compared the effects of intranasal ketamine with intravenous ketorolac in cases of headache. Patients who were treated with ketamine had less severe headache than those treated with ketorolac. However, ketamine caused more side effects in the form of weakness [1].

Shimonovic et al. compared IN ketamine with morphine administered intramuscularly or via a vascular catheter, which were used as painkillers after injuries. The study showed that ketamine administered intranasally achieves an analgesic effect similar to morphine. Due to its rapid and non-invasive form of administration, ketamine can be considered in the treatment of emergencies and injuries in emergency care settings. Additionally, Tongbua et al. in their study proved that IN ketamine does not differ in effectiveness in musculoskeletal pain and can be safely used in the elderly. Its action reduces the need for the use of opioids, which have many side effects [1].

Sufentanil

Sufentanil is a strong, inexpensive synthetic opioid. It has a high therapeutic index – currently one of the highest among opioids [11, 12]. It is 5-10 times stronger than fentanyl and up to 1000 times stronger than morphine. Additionally, it has milder side effects and causes less respiratory depression. It can be administered intravenously, intranasally, sublingually and intrathecally [11]. Morphine, commonly used intravenously in emergency departments, copes very well with severe pain, but is associated with a delay in drug administration. If we want quick, immediate pain relief, we can use Sufentanil spray. In this way, we bypass the procedure of inserting a vascular catheter, and thanks to good vascularization of the nasal mucosa and bypassing the first-pass effect, the drug effectively relieves pain [13]. Studies have shown that intranasal sufentanil is no worse than intravenous morphine in relieving pain within 30 minutes, and its simple route of administration allows for control and rapid reduction of pain symptoms [11-13]. Unfortunately, despite studies on the intranasal use of sufentanil in hospital emergency departments, it is still not widely used [12].

INTRANASAL TREATMENT OF OPIOID OVERDOSE

Opioid epidemic continues to be a significant worldwide health issue. Global health assessments from 2017 suggest that 40.5 million people suffered from opioid dependence and approximately 109,500 individuals lost their lives as a result of opioid overdose [14].

Naloxone is a form of opioid antagonist intended for rapid administration in emergency overdose situations. Naloxone administered via injection has been made available as take-home naloxone (THN), and the introduction of potent intranasal versions is now underway [15]. Nonetheless, there is still no clear consensus on the preferred route or dosing for use in overdose situations

[16]. Skulberg et al. conducted a comparative study between an intranasal naloxone formulation (1.4 mg/0.1 mL) and an intramuscular dose of 0.8 mg/2 ml. Among 201 analyzed participants, spontaneous breathing was restored within 10 minutes after a single dose in 97.2% people (n=105) from the intramuscular group and in 79.6% people (n=74) from the intranasal group. The intranasal group also showed a 19.4% higher risk of requiring a second dose. These results indicate that intranasal naloxone was less effective than intramuscular naloxone in a prehospital setting [17]. However, the mode of delivery plays a critical role in user compliance. McDonald et al. reported that 72.4% of surveyed individuals found the nasal spray the easiest to handle, and 73.5% confirmed they would be willing to use it during an opioid overdose incident [15].

Another medication approved by the U.S. Food and Drug Administration (FDA) in 2023, for emergency use in cases of known or suspected opioid overdose in patients aged 12 and above is nalmefene hydrochloride nasal spray [18]. Intranasal nalmefene outperformed naloxone in reducing cardiac arrests after simulated fentanyl and carfentanil overdoses, with similar effects observed in opioid-naive individuals [19].

CHARACTERISTICS OF INTRANASAL MEDICATIONS IN THE TREATMENT OF EPILEPSY

Epilepsy is a neurological disorder characterized by the occurrence of recurrent seizures that happen without a known trigger, due to disrupted electrical activity in the brain. Interrupting seizure activity promptly is crucial to prevent potential complications such as prolonged seizures or progression to status epilepticus [20]. Optimal rescue therapies should be easy to administer, effective in low doses (with a wide therapeutic range), and have a quick onset that remains active for several hours [20, 21]. The FDA has approved three rescue treatments in the United States for managing seizure clusters: diazepam rectal gel, midazolam nasal spray, and diazepam nasal spray. Intranasal formulation offers a valuable alternative to rectal administration, being simple to use, socially acceptable, and demonstrating a quick onset of action [20]. Midazolam nasal spray (Nayzilam) received approval in May 2019 for patients aged 12 years and older and Diazepam nasal spray (Valtoco) was approved in January 2020 for patients aged 6 and above [20, 22, 23]. Detyniecki et al., in their randomized, double-blind, placebo-controlled trial, assessed 5–10 mg doses of intranasal midazolam for stopping seizure clusters and found it effective in about 54% of cases within the first 10 minutes, while the placebo group showed a 34% success rate [24,25]. In a retrospective study conducted by Owusu KA et al., intranasal midazolam was found to be as effective as intravenous lorazepam in terminating seizures and preventing seizure clusters in adult epilepsy monitoring units [24, 26]. What is more, an open-label pharmaco-EEG study provided evidence for the use of intranasal midazolam in status epilepticus treatment. The study showed that seizures were terminated in 57% of cases, with an average response time of 5 minutes [24, 27].

As far as diazepam is concerned, Hogan RE et al. reported in a pharmacokinetic study that patients received diazepam via nasal spray exhibited less intrapatient variability than those given the rectal gel formulation [20, 28]. The safety study on the long-term use of diazepam nasal spray was published in 2021. Diazepam nasal spray was used 4390 times to treat 3853 seizure clusters, and in 485 cases, a second dose was needed within 24 hours. The monthly average usage was one to two doses for 53.4% of patients, two to five doses for 41.7%, and more than five doses for 4.9%. No serious adverse events related to treatment were observed; the most frequently observed mild side effects included nasal discomfort (6.1%), headache (2.5%), and taste disturbances, nosebleeds, and drowsiness (each reported in 1.8% of patients). The safety profile of diazepam nasal spray was similar across different subgroups based on age, dosage frequency, and use of concomitant medications [20, 29]. According to the study's survey, patients and caregivers expressed satisfaction with diazepam nasal spray and felt more at ease using it publicly compared to rectal diazepam gel. Some patients, including those as young as 11, reported administering the nasal spray on their own [20, 30].

NASAL MEDICATIONS IN THE TREATMENT OF ANAPHYLAXIS

Anaphylaxis is a life-threatening allergic reaction for which adrenaline administered intramuscularly using autoinjectors such as the EpiPen remains the gold standard of treatment. However, current methods have numerous limitations, including short shelf life, high cost, fear of needles, difficulty in use, and the inconvenience of carrying around. In response to these problems, FMXIN002 was developed, an intranasal powder spray that offers potentially faster absorption, convenience of use, and stability at room temperature for up to 2 years. The study, conducted by Yuval Tal, compared the pharmacokinetics, pharmacodynamics, and safety of FMXIN002 with the traditional EpiPen. The results showed that FMXIN002 3.2 mg administered after allergen challenge reached the maximum concentration in blood after 2.5 minutes compared to EpiPen, which reached it in up to 9 minutes and reached the therapeutic level of 100 pg/mL much faster (1 minute vs. 3 minutes, $p < 0.02$). Furthermore, FMXIN002 after challenge showed higher maximum concentration (Cmax: 1110 vs. 551 pg/mL) and greater exposure to the drug (AUC: 672 vs. 431 hours pg/mL), although these differences did not reach statistical significance due to the small sample size. The preparation was well tolerated, and adverse events such as nasal flushing and headache were mild and resolved spontaneously. An additional advantage of FMXIN002 is its stability at room temperature for 2 years, which is a significant advantage over autoinjectors, where this time period is 12 to 18 months. Despite promising results, the

study had some limitations, including small sample size, lack of representation of special populations (e.g., children, obese individuals), and the fact that participants were healthy volunteers rather than patients experiencing anaphylaxis.

Although the data look favorable, further studies with higher doses (e.g., 4 mg) and a broader group of participants are needed to confirm efficacy and reduce interindividual variability. The conclusions suggest that FMXIN002 has the potential to be a breakthrough alternative to current methods of epinephrine administration, offering faster onset, convenience of use, and improved compliance, particularly among adolescents and those avoiding autoinjectors [31].

THE USE OF NASAL MEDICATIONS IN PEDIATRIC PATIENTS

Severe and sudden pain is a common reason for admitting children to the pediatric emergency department. It can also be the main complaint in young patients [10, 32]. Pain management is important not only for medical reasons but also for psychological reasons. Experiencing strong painful stimuli during a stay in a hospital emergency department, mainly by children, can cause negative associations and promote the development of anxiety reactions, increased stress levels and traumas in the future. Pain management is therefore an important element of comprehensive medical care [10, 32, 33]. According to studies, adult patients receive pain treatment more often than pediatric patients, who require it due to difficult contact with the patient and fear of administering medications [10]. For this reason, in children there is a risk that the pain will not be adequately reduced [32].

There are many ways to administer pain medications. The parenteral route is fast and safe. However, it involves an intramuscular injection or administration of the drug through a vascular catheter, which may cause unpleasant sensations in the young patient and unnecessary stress [10, 32, 33]. Oral administration of drugs causes a delay in action and is associated with cooperation with the patient [33]. Drugs administered intranasally are characterized by a very fast onset of action and effective absorption. Additionally, its form of administration is painless and does not cause anxiety in children [10, 32, 33]. They can also be used regardless of the consumption of beverages and food.

In the form of IN (intranasal) administration, one of the most commonly used drugs is Midazolam. It has a sedative effect, but it has no analgesic effect [10]. Due to its very good analgesic properties, ketamine and fentanyl are used in intranasal form [10, 32]. Intranasal analgesics are effective in moderate to severe pain and can be used instead of invasive forms, so they are worth considering when choosing the route of drug administration [32]. Additionally, studies have shown that intranasal midazolam can be safely combined with intranasal fentanyl, which allows for effective sedation during short procedures in children [33].

OTHER INTRANASAL MEDICATIONS IN EMERGENCY MEDICINE

Intranasal drug delivery is becoming increasingly important in the treatment of both local and systemic conditions, especially when rapid action is required. In recent years, a number of innovative systems have been developed to enhance absorption and modulate the pharmacokinetics of intranasal drugs, such as CPE-215®, Intravail®, ChiSys™, PecSys™ and CriticalSorb™. Each of them has a unique mechanism of action, for example CPE-215® increases insulin absorption, achieving a relative bioavailability of 12-19%, while Intravail®, based on tetradecylmaltoside, can improve peptide and protein absorption even above 50%. ChiSys™, using chitosan, works by opening tight junctions in the mucosa, as confirmed in studies with intranasal morphine, where bioavailability was 56%. PecSys™, based on pectin, modulates pharmacokinetics by extending the drug release time, which was used in the PecFent® preparation with fentanyl, providing analgesic effect after 5 minutes. CriticalSorb™ significantly increases the absorption of large molecules, such as human growth hormone, achieving bioavailability of 50% in preclinical studies [34]. Etripamil, a fast-acting intranasal calcium channel blocker, is a breakthrough in the treatment of paroxysmal supraventricular tachycardia (PSVT) and atrial fibrillation with rapid ventricular response (AF-RVR) [35,36]. Clinical studies have shown that after intranasal administration of 70 mg etripamil, statistically significant restoration of sinus rhythm is observed in about 60-70% of patients with PSVT after 15 minutes, with this effectiveness increasing to 75-80% after 30 minutes [36]. In the case of AF-RVR, the drug causes a mean reduction in ventricular rate of about 30 beats per minute, with a median time to maximum effect of only 13 minutes [35]. The use of etripamil is associated with local adverse effects, which include nasal discomfort, mucosal congestion, epistaxis, and dizziness, but no serious arrhythmic events have been reported [35, 36]. Thanks to the possibility of self-administration, the drug can significantly reduce the need for hospitalization, which is confirmed by the results of studies, where patients less often required additional medical intervention [35 ,36]. Current limitations mainly concern the lack of data on long-term use and efficacy in permanent atrial fibrillation, but etripamil seems to be a promising therapeutic option combining rapid action with convenience of administration [35, 36]. Renal colic, which is a common cause of emergency room visits, requires rapid and effective pain management. In a randomized clinical trial of 240 patients, the efficacy of intranasal desmopressin (40 µg) was compared with intravenous acetaminophen (15 mg/kg) in relieving pain. Results showed that both methods significantly reduced pain intensity as measured by a visual analogue scale (VAS) at 30 and 60 minutes, but desmopressin acted more rapidly, providing clinically significant pain relief after 15 minutes. The mechanism of action of desmopressin may involve inhibition of urinary tract smooth muscle contractions and stimulation of β-endorphin production in the

hypothalamus. Both desmopressin and acetaminophen were well tolerated, and the requirement for additional analgesia (morphine) did not differ significantly between groups. Intranasal desmopressin offers additional advantages, such as ease of administration and no need for intravenous access, which may be particularly useful in the emergency setting. Despite promising results, the study had some limitations, including the lack of a placebo control group and assessment of long-term effects of treatment. The conclusions suggest that desmopressin may be an alternative to traditional therapies, especially when rapid analgesia is required, but further studies with larger patient groups are necessary [37]. Despite promising results, intranasal drug delivery systems still face challenges, such as interindividual variability, long-term tolerability, and a limited number of approved preparations [34]. It remains crucial to verify the efficacy and safety of the preparation in different patient populations [34-37]. The future may bring the development of intranasal drug delivery to the central nervous system, bypassing the blood-brain barrier, and the introduction of further innovative therapies [34].

DISCUSSION

The nasal epithelium covers 3-5% of its surface, is very well vascularized, allows the drug to pass directly to the CNS, and the drug is absorbed within 30 minutes. It should be noted that in the case of intranasal administration, the volume of effectively absorbed preparation is limited. Administering too high a dose may result in the transfer of excess drug to the nasopharynx. For this reason, precise control of dosage is necessary and adjustment of the volume and concentration of the drug to the absorption capacity of the nasal mucosa is necessary. Drug absorption also depends on the anatomy of the nasal cavity, drug properties and form of administration. The use of a mucosal spray (MAD) is more effective than administration of the drug in the form of drops, due to lower drug losses and larger amounts of substances reaching the CNS [10]. Administration of the drug via the nasal route is quick, safe and non-invasive [3, 10, 32, 33]. It is a very good option instead of drugs administered intravenously, subcutaneously or intramuscularly. Additionally, the drug bypasses the first-pass effect of drug metabolism occurring in the liver [13, 32].

IN drugs are very effective in emergency pre-hospital treatment and in hospital emergency departments. These drugs can be administered regardless of the patient's age, weight or ability to cooperate with us. Thanks to this, we can also successfully use them in pediatric patients [3, 10]. Pain management is particularly important in emergency care, and the intranasal route of administration has many potential applications here, due to the rapid onset of the drug's action [1, 3, 10]. Intranasal drugs are becoming increasingly widely used in emergency care. Many substances have appeared that we can use IN. A wide range of such drugs is available, including: fentanyl, midazolam, glucagon, diamorphine, naloxone and ketamine [3]. Administration of IN naloxone can reverse the adverse effects of opioids, including complications requiring immediate action such as respiratory depression. [32]. Intranasal administration of drugs is also used in the emergency treatment of epileptic seizures. Especially in cases where rapid termination of the attack is crucial and access to the intravenous route is difficult or impossible [20]. There have also been reports on the treatment of anaphylaxis using a nasal spray with epinephrine. This spray serves as an alternative needle-free therapeutic option [31]. Due to the limited number of available studies on midazolam, diamorphine and glucagon, there is a need to deepen the knowledge in this area through further scientific research [3]. Studies indicate that ketamine, sufentanil and fentanyl administered intranasally may be a safe and effective alternative to their intravenous form in the treatment of pain [1, 11, 12]. Unfortunately, despite promising studies and scientific reports, the use of intranasal analgesics is not popular due to the low knowledge of the drugs and the small number of conducted trainings [2].

Intranasal drugs are also used in long-term care. Studies have shown that dexmedetomidine can be used as an alternative to subcutaneous opioids. This drug effectively reduces pain in geriatric patients, while having a favorable safety profile. Thanks to its non-invasive and painless form of administration, it increases the comfort of patients requiring constant pain treatment and improves the quality of palliative care [38].

CONCLUSIONS

Intranasal drug administration is increasingly recognized as a practical and non-invasive alternative method, particularly in scenarios requiring rapid therapeutic action. This route is especially advantageous in pediatric populations due to ease of use and patient compliance. The onset of action of certain intranasal medications may be delayed relative to intravenous formulations; therefore, drug selection should be tailored to the clinical context. However, challenges such as interindividual variability, long-term tolerability, and the limited availability of approved intranasal formulations persist. Future innovation could bring about entirely different approaches to treatment.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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CASE STUDY

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Cardio-pulmonary arrest in acute cyanide poisoning - case report

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ABSTRACT

Potassium cyanide is a highly toxic compound that interferes with cellular respiration, leading to rapid and severe poisoning. Its lethality has made it notorious in suicides, homicides, and executions. The increasing accessibility of cyanide through online platforms highlights an emerging public health concern. Although infrequent, cyanide poisoning requires rapid, coordinated responses due to its acute effects. This report presents a case of cyanide poisoning in a 36-year-old woman, illustrating key clinical features and highlighting areas for improvement in emergency response protocols to support more timely, life-saving interventions. This case study highlights the tragic outcome of a woman admitted to the Emergency Department following a suicide attempt with potassium cyanide. Upon admission, the patient was resuscitated by the emergency medical team. The clinical presentation was characterized by cardiopulmonary arrest, asystole on ECG, cherry-red skin on the head and shoulders, and dilated, unresponsive pupils. Despite medical intervention, including hydroxocobalamin and activated carbon administration, blood transfusions, and hyperkalemia treatment, the patient did not respond to resuscitation efforts. Due to prolonged CPR, the patient was disqualified from ECMO therapy, and approximately an hour after admission, her death was confirmed. Cyanide poisoning, while not commonly utilized in suicide attempts, presents a significant challenge in emergency medicine due to its rapid onset and lethal consequences. This case study underscores acute cyanide poisoning as a potential cause of cardiac arrest.

KEY WORDS

cyanide poisoning, suicide attempt, toxicological emergency, hydroxocobalamin, cardiopulmonary arrest

INTRODUCTION

The increasing accessibility of toxic substances, including potassium cyanide via online platforms, highlights an emerging public health concern. Cyanide-related incidents, although infrequent, require rapid, coordinated responses due to their acute and often fatal effects. This report presents a case of acute cyanide poisoning in a 36-year-old woman, illustrating hallmark clinical features of cyanide toxicity and drawing attention to areas within emergency response protocols where improvements could support more timely, life-saving interventions. The findings underscore the importance of strengthened collaboration among emergency responders, toxicology centers, and healthcare facilities to ensure optimal treatment and improve outcomes in similar high-risk cases.

Cyanide poisoning is a critical toxicological emergency due to its severe impact on cellular respiration. By inhibiting cytochrome c oxidase within the mitochondrial electron transport chain, cyanide halts oxidative phosphorylation, forcing cells to rely on anaerobic metabolism. This shift leads to the accumulation of lactic acid, metabolic acidosis, and an increased anion gap [1]. The diverse clinical presentation and potential for a wide range of differential diagnoses pose significant challenges for clinicians. Key signs of cyanide poisoning include profound central nervous system and cardiovascular system dysfunction [2].

Although cyanide poisoning has historically been linked to unintentional occupational intoxications and fire smoke intoxications, it is also a growing chemical hazard, with ingestion being the most frequent mode of exposure [3, 4]. Serum cyanide levels can take a long time to obtain; therefore, clinical symptoms and serum lactate levels are often used to guide clinical judgment and the antidotes administration [5]. Threats from terrorist groups to target food and water supplies raise concerns about bioterrorism involving potential cyanide poisoning. Cyanide can easily be concealed in food and water, making mass poisoning a realistic and dangerous possibility [3].

Despite immediate symptomatic treatment, emergency procedures, and decontamination efforts, the prompt administration of an antidote remains crucial. Hydroxocobalamin is the preferred treatment, but if unavailable, alternatives such as sodium nitrite or amyl nitrate, and sodium thiosulfate may also be employed [6–8].

Fig. 1. Characteristic cherry-red discoloration of the face observed during resuscitation

Fig. 2. Characteristic cherry-red discoloration of the upper extremities observed during resuscitation

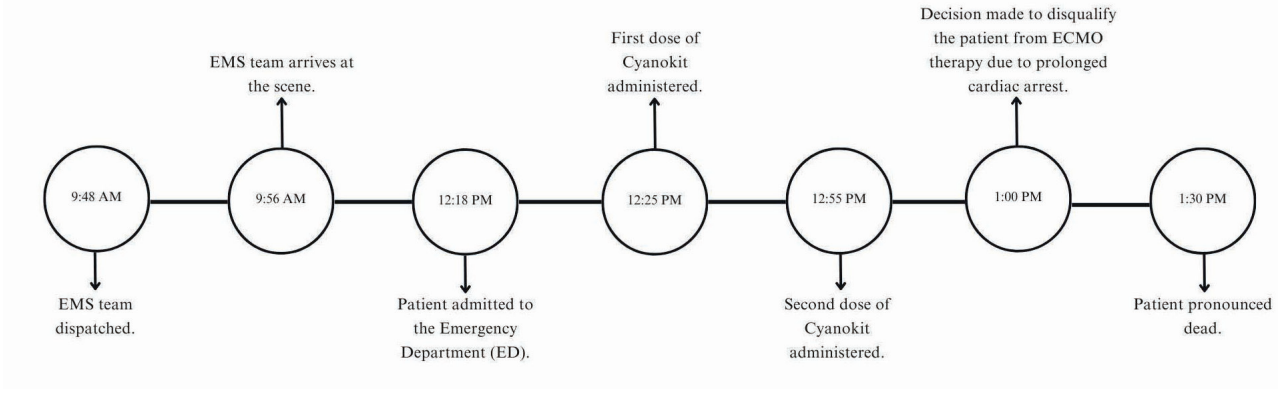

Fig. 3. Timeline of key events

CASE REPORT

A 36-year-old female with a history of depression, currently on antidepressants and antipsychotics (Trittico, Citabax, and Perazin), was found by her family lying supine on the floor. A suicide note was discovered at the scene, raising suspicion of a suicide attempt via cyanide ingestion. Cardiopulmonary resuscitation (CPR) was initiated by the bystanders. The emergency medical services (EMS) team arrived promptly and conducted an initial assessment. Upon their arrival, the patient was in cardiac arrest, exhibiting pulseless electrical activity (PEA), which later progressed to asystole. Despite the absence of significant dermatological changes initially, subsequent observation in the Emergency Department during resuscitation revealed a distinctive cherry-red discoloration on the face, arms, and upper extremities—characteristic but uncommon present in approximately 11% of cases in cyanide poisoning [9]. The facial discoloration is shown in Figure 1,

while the changes in the upper extremities are presented in Figure 2. Another hallmark feature, the presence of a characteristic bitter almond odor, was not observed.

CPR was performed in accordance with advanced life support (ALS) guidelines, including mechanical chest compressions and endotracheal intubation for mechanical ventilation. A labelled container with cyanide was found at the scene. It remains unclear whether sputum samples or contents of poison container were specifically collected and analysed. Although the fire department confirmed having the capability to perform Raman spectroscopy analysis, their refusal to provide the report from the scene made it impossible to verify the analysis. Medications, as per ALS protocols, were administered, and the patient was transported to the hospital while remaining in cardiac arrest. Upon arrival at the emergency department (ED), the patient remained in asystole with dilated, nonreactive pupils. Further assessment revealed severe hyperkalemia and metabolic acidosis, consistent with cyanide poisoning. The analysis of venous blood biochemical tests is summarized in Table 1, while the arterial blood gas analysis is shown in Table 2.

During ongoing CPR, a gastric tube was inserted, and approximately 700 ml of bloody gastric secretions were aspirated, suggesting gastrointestinal involvement. Two units of packed red blood cells were transfused, and activated charcoal was administered to mitigate further absorption of the ingested toxin. In line with the recommended treatment protocols, hydroxocobalamin (Cyanokit) was administered as the antidote. The initial dose of 5 grams was given over 15 minutes, followed by a second 5-gram dose shortly after. Despite these interventions, the patient remained in a state of cardiac arrest throughout the treatment process, leading to disqualification from ECMO therapy, ultimately resulting in the patient's demise.

The timeline of the incident indicated a prolonged period of cardiac arrest prior to admission. The EMS team was dispatched at 9:48 AM, arriving at the scene by 9:56 AM. The patient was admitted to the ED by 12:18 PM, with the first dose of Cyanokit administered at 12:25 PM and the second at 12:55 PM. The decision was made to disqualify the patient from extracorporeal membrane oxygenation (ECMO) therapy due to the extensive duration of the cardiac arrest. At 1:30 PM, the patient was pronounced dead. The timeline of key events has been summarized in Figure 3.

DISCUSSION

In this report, we present a rare case of acute and fatal cyanide poisoning. While ingestion of potassium cyanide is an uncommon method of intoxication, it remains a possible route alongside industrial accidents and fire-related exposures [10]. According to research by Sang Ki Lee et al., among 255 cases of cyanide poisoning, 97.3% were classified as suicide attempts, with approximately 51.8% of these incidents occurring in individuals aged 30-49 years [11]. Comparable findings were reported by Maryam Akhgari et al., who noted that 61.5% of cyanide poisoning cases occurred in the 21-40 year age group, and 63.5% were suspected to be suicide attempts [12]. Diagnosing cyanide poisoning remains challenging for healthcare professionals; however, there are certain clinical signs that may aid in the diagnostic process. Severe intoxication typically manifests as cardiovascular and central nervous system abnormalities.

Most patients develop cardiac complications, with approximately 95% of those in cardiac arrest initially presenting with asystole and 5% with ventricular fibrillation. This contrasts with pulseless electrical activity (PEA), which was the initial rhythm observed in this case [2]. The classic cherry-red skin discoloration, typically associated with cyanide toxicity and noted in this case, is a rare finding, present in only 11% of reported cases [9]. In this patient, however, the discoloration manifested with a delay, and its absence at the initial presentation did not contribute to early diagnostic suspicion.

In addition to physical examination, elevated lactate levels and increased central venous oxygen saturation are among the most commonly observed laboratory findings. Although hyperlactatemia is not a specific marker of cyanide poisoning, abnormally high venous PO2 may suggest its presence. Elevated venous PO_2 occurs due to reduced oxygen uptake by peripheral tissues [13, 14]. In this patient, only arterial blood gas analysis was performed, which revealed evidence of metabolic acidosis. Gastrointestinal involvement, such as hemorrhagic gastritis, can result from the ingestion of cyanide salts, as was likely observed in this patient. This typically occurs only in cases of prolonged intoxication [6, 15]. Suspicion of lethal poisoning arose after paramedics discovered a suicidal note mentioning the ingestion of a solution that was believed to contain potassium cyanide. This was later supported by the discovery of a container labeled with cyanide at the scene. Treatment was initiated immediately upon the patient's admission to the emergency department while the patient remained in a state of cardiac arrest.

Despite the uncertain efficacy of activated charcoal, a study by Richard J. Lambert et al. suggests that its administration can be beneficial in animal models if implemented promptly after intoxication [15, 16]. However, in our case, no desirable effects were observed. Hydroxocobalamin was promptly administered upon admission as the treatment of choice for suspected cyanide poisoning [17]. Unfortunately, despite all interventions performed in the emergency department, the patient did not survive.

CONCLUSIONS

In cases of poisoning, timely treatment of the underlying cause is critical, emphasising the importance of prompt antidote administration. Due to the rarity of cyanide intoxication, decisions made at the scene delayed the initiation of the antidote, which could have affected the patient's prognosis. Implementing the option of delivering essential medications directly to the scene could be a valuable strategy in managing similar cases in the future.

Table 1. Results of the patient's venous blood tests

Laboratory tests	Units	Reference range values*	Patient's results
Hb	mmol/l	7.4 - 9.9	8.0
Hgb	[g/dl]	12.0 - 16.0	12.9
Hct	[%]	34.0 - 45.0	42.6
RBC	[mln/µl]	4.00 - 5.50	4.08
MCV	[fl]	80.0 - 100.0	104.4
WBC	[K/µl]	4.0 - 11.0	4.6
Na	[mmol/l]	135 - 148	141
PLT	[K/µl]	130 - 440	191
K	[mmol/l]	3.50 - 5.30	9.7
Creatinine	[µlmol/l]	44 - 88	150
eGFR (MDRD)	[ml/min/1,73 m^2]	-	36.3
Glucose	[mmol/l]	3.9 - 5.5	17.2
AST	[U/L]	4 - 35	65
INR	-	0.80 - 1.20	1.1
aPTT	[s]	24.0 - 35.0	50.0
D-dimer	[µg/ml FEU]	0.00 - 0.50	99.63

Hb: Hemoglobin; Hgb: Hemoglobin concentration; Hct: Hematocrit; RBC: Red blood cells; MCV: Mean corpuscular volume; WBC: White blood cells; Na: Sodium; PLT: Platelets; K: Potassium; eGFR (MDRD): Estimated glomerular filtration rate (Modification of Diet in Renal Disease); AST: Aspartate aminotransferase; INR: International normalized ratio; aPTT: Activated partial thromboplastin time

*Reference range values provided by the hospital-associated laboratory.

Table 2. Results of the patient's arterial blood gas analysis

Laboratory tests	Units	Reference range values*	Patient's results
pH	-	7.35 - 7.45	6.757
H^+	[nmol/l]	35.0 - 45.0	175.0
PCO_2	[kPa]	4.67 - 6.00	3.57
$P0_2$	[kPa]	11.10 - 14.40	34.70
SO_2	[%]	-	95.8
BE	nmol/l	-3.5 - 3.5	-32.8
HCO_3-	[nmol/l]	21.0 - 28.0	3.6

H^+: Hydrogen ion concentration; PCO_2: Partial pressure of carbon dioxide; $P0_2$: Partial pressure of oxygen; SO_2: Oxygen saturation; BE: Base excess; HCO_3-: Bicarbonate concentration

*Reference range values provided by the hospital-associated laboratory.

Rapid communication between the emergency team and the toxicology center, along with the transport of the antidote directly to the scene, not only allows for faster administration, increasing the chances of successful treatment, but also opens possibilities for considering advanced therapeutic options such as ECMO in severe poisoning cases. Further research is needed to assess the current state of knowledge on rare poisonings and emergency protocols, as well as to develop efficient communication and operational algorithms in such cases. Consideration should be given to the establishment of dedicated facilities for managing patients with hazardous substance exposures to prevent contamination of entire hospital units and thus maintain the capacity to assist other patients.

LIMITATION OF THE STUDY

In this study, lactate levels and venous blood oxygenation were not measured, and it was not possible to determine cyanide concentration during the time in ED.

LIST OF ABBREVIATIONS:
ECG – Electrocardiogram
CPR – Cardiopulmonary Resuscitation
ECMO – Extracorporeal Membrane Oxygenation
ED – Emergency Department;
EMS – Emergency Medical Services
ALS – Advanced Life Support
PEA – Pulseless Electrical Activity
CNS – Central Nervous System
PO_2 – Partial Pressure of Oxygen

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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