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ORIGINAL PAPER

PATIENT RIGHTS IN SELF-ASSESSMENT OF NURSES AND PARAMEDICS OF HOSPITAL EMERGENCY DEPARTMENTS

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ABSTRACT

INTRODUCTION: In Poland, the function of accident admissions is performed by admission rooms and hospital emergency departments. The outbreak of the COVID-19 pandemic in 2020 has radically changed the functioning of the healthcare system. The introduction of the state of epidemic emergency in Poland, followed by the state of the epidemic, was the basis for imposing several restrictions that had a significant impact on the execution of patients' basic rights.

The aim of this study was the analysis of the attitudes exhibited by the emergency department medical personnel regarding the rights held by patients.

MATERIAL AND METHODS: The study involved 124 respondents employed in hospital emergency departments. The participants of the study were selected in such a way that paramedics accounted for half (50%) of the participants and nurses constituted the other half. In the study group, males accounted for 54.8% of the participants, while females accounted for 45.2%. 41.1% of respondents held a master's degree, 25% declared higher professional education and 33.9% declared vocational secondary vocational education. The research used the following methods: a diagnostic survey, anonymous surveys, and a self-developed questionnaire consisting of 15 questions. The statistical analysis was carried out in the Statistica SPSS — IBM SPSS statistical package (Version 28.0.1.0; IBM Corporation, SPSS Inc., Chicago, IL, USA). For the analysis of the gathered quantitative data, differentiated concerning the independent variable of education, the non-parametric Mann–Whitney U and the Chi^2 tests were used at a significance level of $\alpha = 0.05$.

RESULTS: According to 74.20% of the participants, they became familiar with patient rights during their work experience, while only 25.80% of them did so during their education. A satisfactory level of knowledge regarding patient rights was found among 58.10% of all respondents. The most familiar patient right among 88.70% of respondents (90.30% of the nurses, 87.10% of the paramedics) is the patient right to health services. 77.40% of participants adhere to patient rights in their daily work. According to 88.70% of respondents, the requirements under patient rights apply to all healthcare professionals. The most common violation in the work process, according to 65.30% of respondents, is the patient right to respect for privacy and dignity of the patient.

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CONCLUSIONS: (1) Almost 90% of respondents expressed the opinion that patient rights concern all healthcare professionals, and circa 80% of them declared that they always adhere to them in their daily professional work. (2) The most familiar patient right among almost all respondents is the right to healthcare services, while the least familiar is the patient right to store valuables in the depository. (3) The statistical analysis carried out for this study did not show any statistically significant differences in the presented level of knowledge and declared attitudes concerning patient rights, taking into account the division between paramedics and nurses.

INTRODUCTION

The execution of emergency medical procedures takes place in separate emergency areas of the hospital, most often organized as hospital emergency departments (EDs) or the admission room. The ED plays a special role in the healthcare system. It is a unit of the State Emergency Medical Service (SEMS) system, which is an organizational unit of the hospital that carries out healthcare services to people in states of sudden threat to their lives or health. EDs are primary units equipped with specialized equipment which enables almost any life-saving medical procedure to be carried out. Within the ED, there are specialized and highly qualified medical personnel with access to equipment and facilities that enable them to carry out resuscitation, surgical and also diagnostic activities [1].

The primary task of the ED is to bridge the gap between the pre-hospital management of patients requiring health services and hospital treatment. These services consist of initial diagnosis and initiation of treatment (involving stabilization of basic vital functions) for patients whose life or health is threatened [2].

In terms of the right to health care services, it is irrelevant whether the patient arrived at the ER by their own means or was brought in by the ERT. Each patient who presents at the ER should be admitted. The healthcare entity within which the ED operates cannot refuse to provide health services to a patient who needs such services due to a threat to life or health. In particular, organizational issues cannot be the reason for refusing to provide a health service [3].

The functioning of the ED is unique because of its constantly dynamic nature. Several emergency response teams (ERTs) may arrive in a short period with patients in need of immediate assistance. It is also worth noting that patients present to the ED by their own means, as well. The task of the ED

is to diagnose patients whose life is threatened on an ad hoc basis. It should be noted that the actual treatment takes place in the hospital [4].

At times, dozens of people in need, of various ages and in different states, are in the ED waiting room at the same time. Such a number of patients in one place and the growing queue very often cause frustration and aggression. People who present at the ED, but do not require immediate assistance reduce the actual level of health security by blocking queues and preventing the injured people who really need help from receiving it immediately. These situations, however, do not mean that patient rights do not apply within the execution of health services by the ED medical personnel.

According to the Supreme Audit Office (SAO), the COVID-19 pandemic exposed the fact that hospitals existing within the public healthcare system were not prepared to function under emergency conditions. At the facilities inspected by the SAO, the provision of certain services had been restricted or temporarily suspended [5].

Unfortunately, in the face of a biological threat such as the COVID-19 pandemic, hospitals, including the EDs, failed to ensure that all health needs would be met, despite the many solutions implemented [6].

The significance and importance of proper functioning of EDs as a matter of public health and patient healthcare can be evidenced, *e.g.* by data gathered by Statistics Poland (SP) on health services provided by EDs in the years 2022–2023. As the SP's data shows, at the end of 2022 there were 244 EDs operating within the SEMS system, providing health services in both outpatient mode (without hospitalization) and inpatient mode. Furthermore, 157 admission rooms in which health services were provided in outpatient mode cooperated with the SEMS system in 2022. Almost 3.8 mln people received outpatient care in the ED or admission

rooms. The number of inpatients treated in the ED amounted to more than 1.8 mln. In 2022, 147 people per 1,000 population were provided with health services in the ED or the admission room. Children and adolescents under the age of 18 accounted for 19.4% of the total number of people treated in admission rooms or the ED, and people aged 65 and over accounted for 27.1%. Patients treated in the outpatient mode most often received services in trauma and orthopaedic surgery (24.3% of those treated), general services (20.6%) and surgery (17.1%). The number of EDs and ARs is shown in Table 1 [7].

As shown in the Patient Rights Ombudsman Report (PRO) "Contents of reports directed to the Patient Rights Ombudsman Hotline in 2021" [8], reports directed to the Telephone Patient Information (TPI) regarding some of the inpatient treatment services registered in the years 2020–2021 by the scope of services showed that 3760 reports regarding ED emergency medicine irregularities were registered in 2020, which accounted for 19% of all reports, whereas in 2021 there were one-third fewer such reports concerning the previous year — only 1,138, which accounted for 5% of all reports. The most frequently reported issues of patients calling TPI about matters regarding the ED are presented in Table 2.

The outbreak of the COVID-19 pandemic has significantly affected the functioning of the healthcare system in Poland, as well as the exercising of several human and civil freedoms and rights, including patient rights. Due to the risk of transmitting the virus, *i.e.* accompaniment (care for) patients in the ED was excluded. During the COVID-19 pandemic patient rights were often restricted, and at times even excluded [9–11]. It is for this reason that medical personnel knowing and applying patient rights in their daily professional work is so crucial when it comes to respecting patient rights, regardless of the existing state of epidemic emergency.

The efficiency of the ED largely depends on the proper segregation of patients in accordance to their health condition or possible injuries, and above all on the separation of patients requiring action in the ED from patients ineligible for such action. Particularly the latter issue assumes great importance for the healthcare system, as it causes congestion in the ED and disrupts its proper functioning, which often results in a violation of patient rights.

Ensuring high quality of health services provided, and setting appropriate standards for operations, including the application of patient rights, are an essential part of the organization of work in entities operating within the healthcare sector. This is important since the quality of healthcare services provided

Table 1. Hospital emergency departments and admission rooms in Poland [7]					
Specification	2018	2019	2020	2021	2022
Hospital emergency departments (EDs)	230	237	239	241	244
Admission rooms (AR)	149	155	154	156	157

Table 2. Issues reported to TPI regarding the functioning of the ED [8]	
Lp.	Reported issue
1.	Denial of additional nursing care and contact with loved ones, due to restrictions of access caused by the epidemic and bans instituted in hospitals
2.	Objections to the standard of provided services
3.	Conditions in which health services were provided
4.	Deprivation of the right to have a support person present during the provision of health services
5.	Questioning a discharge from a hospital emergency department
6.	Failure to take action in transferring the patient to another hospital facility
7.	Long waiting time for the provision of a service in the case of sudden deterioration of health or qualification for treatment
8.	Denial of execution of additional services (*i.e.* medical transport, issuing a certificate of temporary incapacity for work)

translates not only into health, trust or safety but above all into the life of the patient.

MATERIAL AND METHODS

The study was conducted between July and October 2022 among employees of hospital emergency departments in the Silesian Voivodeship. The participants of the study were selected deliberately so that male and female nurses (hereafter — nurse) would account for half of the participants, and male and female paramedics (hereafter — paramedic) for the other half. 140 respondents were willing to participate in the survey. Those interested in participating in the survey were given envelopes containing the research instrument and instructions on how to proceed. Each participant was informed about the subject and purpose of the conducted study. Participation in the study was voluntary and anonymous. Participants received questionnaires during individual meetings at their workplaces (ED). Respondents participated in the study willingly and knowingly. Only data obtained from the 124 respondents who correctly (fully) answered the questionnaire questions were included in the survey analysis. The return of correctly completed questionnaires was obtained at 88.60%. Due to the lack of a standardized research tool with which to diagnose the level of knowledge of medical personnel regarding knowledge and application of patient rights, the research tool used was a survey questionnaire of the authors' own design. The questionnaire consisted of 15 questions. The first part of the questionnaire dealt with sociodemographic data concerned with data such as gender, age, education, and length of work experience, while the second part contained 11 questions on specific data concerning knowledge and application of patient rights in daily professional practice. The questionnaire was not validated beforehand, as the research was preliminary. The survey was conducted by the principles of the Declaration of Helsinki [12].

A Microsoft Excel spreadsheet (Microsoft Office) was used to statistically process the results. The statistical analysis was carried out in the Statistica 13.1 PL statistical software (Jan Kochanowski University of Kielce license). For the analysis of the gathered quantitative data, differentiated concerning education, the non-parametric Mann–Whitney U and the Chi^2 tests were used at a significance level of $\alpha = 0.05$.

RESULTS

In the study group, males were slightly in the majority (54.8%). Women accounted for 45.2% of the respondents. The largest number of respondents (41.1%) had a master's degree, these were mainly people in the nursing profession. One in three respondents (33.9%) had secondary vocational education (post-secondary school), with those in the nursing profession being in the majority in this group, and one in four (25%) had higher professional education (bachelor's degree), in this group paramedics outnumbered the nurses.

A correlation analysis was performed. For this purpose, Cramér's V was used as a correlation coefficient for variables nominal in nature.

1. A relationship was identified between satisfaction with one's level of knowledge regarding patient rights and compliance with those rights (Cramér's V correlation coefficient = 0.451; p < 0.001).
2. A relationship was identified between the subjectively evaluated satisfaction with one's level of knowledge regarding patient rights and the likelihood of noticing patient rights violations in the workplace (Cramér's V correlation coefficient = 0.472; p < 0.001).
3. Subjectively evaluated satisfaction with one's level of knowledge regarding patient rights correlated with the knowledge of the WHO Patient's Rights Charter (Cramér's V correlation coefficient = 0.286; p < 0.001), the European Charter of Patients' Rights (Cramér's V correlation coefficient = 0.286; p < 0.001) and the Act on the Patient Rights and the Patient Rights Ombudsman (Cramér's V correlation coefficient = 0.378; p < 0.001). Such a relationship was not identified for the knowledge of the Constitution of the Republic of Poland (Cramér's V correlation coefficient = 0.007; p > 0.05).

Detailed results relating to the knowledge and application of patient rights in the daily professional practice of the respondents according to their medical profession are shown in Table 3.

Research shows that among all the respondents, 74.20% became familiar with patient rights during work (nurses — 72.60%, paramedics — 75.80%), whereas only 25.80% did so during their education (respectively 27.40% and 24.20%). A satisfactory level of patient rights knowledge was declared by 58.10% of all respondents, including 65.90% of the nurses and 54.80% of the paramedics participating

Lp.	Question	Answer	Profession (w %) n = 124 (100.00)		Chi^2	p value*
			Nurses n = 62 (50.00)	Paramedics n = 62 (50.00)		
		Total	n = 62 (100.00)	n = 62 (100.00)		
1.	Where did you become familiar with patient rights?	During education	17 (27.40)	15 (24.20)	0.168	0.681
		During work	45 (72.60)	47 (75.80)		
2.	How would you evaluate your knowledge of patient rights?	Unsatisfactory	24 (38.70)	28 (45.20)	0.300	0.584
		Satisfactory	38 (65.90)	34 (54.80)		
3.	Have you familiarized yourself with the legal act regulating patient rights in Poland? (More than one answer can be indicated)	WHO Patient Rights Charter				
		Yes	5 (8.10)	8 (12.90)	0.773	0.379
		No	57 (91.90)	54 (87.10)		
		European Charter of Patient Rights				
		Yes	6 (9.70)	7 (11.30)	0.086	0.769
		No	56 (90.30)	55 (88.70)		
		Act on the Patient Rights and the Patient Rights Ombudsman				
		Yes	34 (54.80)	39 (62.90)	1.192	0.275
		No	28 (45.20)	23 (37.10)		
		The Constitution of the Republic of Poland				
		Yes	24 (38.70)	29 (46.80)	0.824	0.364
		No	38 (61.30)	33 (53.20)		
		I do not know any such document				
		Yes	4 (6.50)	7 (11.30)	0.898	0.343
		No	58 (93.50)	55 (88.70)		
4.	Are patients informed of their rights in your workplace?	Yes	39 (62.90)	34 (54.80)	0.911	0.340
		No	23 (37.10)	28 (45.20)		
5.	How are patients informed of their rights in your medical facility? (More than one answer can be indicated)	Sign on a notice board				
		Yes	41 (66.10)	48 (77.40)	2.505	0.113
		No	21 (33.90)	14 (22.60)		
		Verbally by medical personnel				
		Yes	27 (43.50)	29 (46.80)	0.130	0.718
		No	35 (56.50)	33 (53.20)		
6.	Please indicate to whom the patient rights requirements concern (more than one answer can be indicated)	Medical facility management				
		Yes	49 (79.00)	51 (82.30)	0.207	0.649
		No	13 (21.00)	11 (17.70)		
		Doctors				
		Yes	53 (85.50)	51 (82.30)	0.238	0.625
		No	9 (14.50)	11 (17.70)		
		Nurses				
		Yes	56 (90.30)	55 (88.70)	0.086	0.769
		No	6 (9.70)	7 (11.30)		
		Paramedics				
		Yes	48 (77.40)	52 (83.90)	0.827	0.363
		No	14 (22.60)	10 (16.10)		
		All healthcare professionals				
		Yes	57 (91.90)	53 (85.50)	1.288	0.256
		No	5 (8.10)	9 (14.50)		

Table 3. Knowledge and application of patient rights in the day-to-day professional practice of respondents according to their profession

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Table 3. (cont.) Knowledge and application of patient rights in the day-to-day professional practice of respondents according to their profession

Lp.	Question	Answer	Profession (w %) n = 124 (100.00)		Chi^2	p value*
			Nurses n = 62 (50.00)	Paramedics n = 62 (50.00)		
		Total	n = 62 (100.00)	n = 62 (100.00)		
7.	Who is accountable for a violation of a patient rights?	Medical facility management				
		Yes	51 (82.30)	54 (87.10)	0.559	0.455
		No	11 (17.70)	8 (12.90)		
		Medical professional guilty of misconduct				
		Yes	49 (79.00)	56 (90.30)	3.046	0.081
		No	13 (21.00)	6 (9.70)		
8.	Please indicate the patient rights you are familiar with (more than one answer can be indicated)	Patient right to health services				
		Yes	56 (90.30)	54 (87.10)	0.322	0.570
		No	6 (9.70)	8 (12.90)		
		Patient right to information				
		Yes	51 (82.30)	53 (85.50)	0.238	0.625
		No	11 (17.70)	9 (14.50)		
		Patient right to report adverse reactions to medicinal products				
		Yes	47 (75.80)	48 (77.40)	0.045	0.832
		No	15 (24.20)	14 (22.60)		
		Patient right to confidentiality of personal information				
		Yes	56 (90.30)	54 (87.10)	0.322	0.570
		No	6 (9.70)	8 (12.90)		
		Patient right to consent to receiving health services				
		Yes	52 (83.90)	53 (85.50)	0.062	0.803
		No	10 (16.10)	9 (14.50)		
		The right to respect for privacy and dignity of the patient				
		Yes	57 (91.90)	56 (90.30)	0.100	0.752
		No	5 (8.10)	6 (9.70)		
		Patient right to medical records				
		Yes	49 (79.00)	51 (82.30)	0.207	0.649
		No	13 (21.00)	11 (17.70)		
		Patient right to raise an objection against the opinion or medical certificate issued by the physician				
		Yes	43 (69.40)	45 (72.60)	0.157	0.692
		No	19 (30.60)	17 (27.40)		
		Patient right to respect for private and family life				
		Yes	58 (93.50)	56 (90.30)	0.435	0.510
		No	4 (6.50)	6 (9.70)		
		Patient right to pastoral care				
		Yes	42 (67.70)	38 (61.30)	0.564	0.453
		No	20 (32.30)	24 (38.70)		
		Patient right to store valuables in the depository				
		Yes	38 (61.30)	29 (46.80)	2.630	0.105
		No	24 (38.70)	33 (53.20)		

→

Lp.	Question	Answer	Profession (w %) n = 124 (100.00)		Chi^2	p value*
			Nurses n = 62 (50.00)	Paramedics n = 62 (50.00)		
		Total	n = 62 (100.00)	n = 62 (100.00)		
9.	Do you comply with the patient rights?	Always	49 (79.00)	47 (75.80)	0.185	0.668
		Sometimes	13 (21.00)	15 (24.20)		
10.	Have you witnessed any violations of patient rights in your workplace?	Yes	51 (82.30)	48 (77.40)	0.451	0.502
		No	11 (17.70)	14 (22.60)		
11.	Do patient rights violations by medical personnel occur in your workplace? If Yes, please indicate the type of violation (more than one answer can be indicated)	Patient right to health services				
		Yes	8 (12.90)	6 (9.70)	0.322	0.570
		No	54 (87.10)	56 (90.30)		
		Patient right to information				
		Yes	13 (79.00)	26 (41.90)	4.409	0.036
		No	49 (21.00)	36 (58.10)		
		Patient right to report adverse reactions to medicinal products				
		Yes	11 (17.70)	16 (25.80)	1.184	0.277
		No	51 (82.30)	46 (74.20)		
		Patient right to confidentiality of personal information				
		Yes	15 (24.20)	19 (30.60)	0.648	0.421
		No	47 (75.80)	43 (69.40)		
		Patient right to consent to receiving health services				
		Yes	7 (11.30)	12 (19.40)	1.554	0.213
		No	55 (88.70)	50 (80.60)		
		The right to respect for privacy and dignity of the patient				
		Yes	37 (59.70)	44 (71.00)	1.744	0.187
		No	25 (40.30)	18 (29.00)		
		patient rights to medical records				
		Yes	6 (9.70)	8 (12.90)	0.322	0.570
		No	56 (90.30)	54 (87.10)		
		Patient right to raise an objection against the opinion or medical certificate issued by the physician				
		Yes	3 (4.80)	0 (0.00)	3.074	0.080
		No	59 (95.20)	62 (100.00)		
		Patient right to respect for private and family life				
		Yes	9 (14.50)	5 (8.10)	1.288	0.256
		No	53 (85.50)	57 (91.90)		
		Patient right to pastoral care				
		Yes	2 (3.20)	0 (0.00)	2.033	0.154
		No	60 (96.80)	62 (100.00)		
		Patient right to store valuables in the depository				
		Yes	4 (6.50)	9 (14.50)	2.148	0.143
		No	58 (93.50)	53 (85.50)		

Table 3. (cont.) Knowledge and application of patient rights in the day-to-day professional practice of respondents according to their profession

Chi-squared test χ; *p < α, statistical significance indicated

in the study. As many as 77.40% of all the participants (79.00% of the nurses and 75.80% of the paramedics) stated that they adhere to patient rights in their daily professional work. The most familiar patient right for 88.70% of respondents (90.30% of the nurses, 87.10% of the paramedics) proved to be the patient right to health services, while the least familiar right is the patient right to store valuables in the depository 52.20% (including 61.30% of the nurses, 46.80% of the paramedics). Requirements under patient rights, according to 88.70% of the respondents (including 91.90% of the nurses, 85.50% of the paramedics), concern all healthcare professionals.

As many as 77.40% of respondents (including 79% of the nurses, 75.80% of the paramedics) stated that in their daily work, they always adhere to patient rights, only 22.60% of respondents (including 21.00% of the nurses, 24.20% of the paramedics) did so sometimes. The results pertaining specifically to the questions regarding patient rights compliance and identification of their violations in the workplace (questions 10 and 11) indicate that the respondents find it difficult to classify negative behaviours, attitudes or actions undertaken by the other members of the medical personnel in regards to specific patient rights.

DISCUSSION

Improving the situation in the ED, and thus increasing the health safety of patients, is possible *e.g.* by increasing the number of medical personnel employed, but also by raising awareness regarding the knowledge and application of patient rights. It should be noted that the patient has not only rights, but also responsibilities, and should therefore be aware of how to utilise the ED.

Many factors determine the quality of the healthcare system. The most important ones undoubtedly include: the availability of medical services, the expertise of medical professionals, the safety of the procedures, the continuity of care, the adaptation of care to needs, and the efficiency of the system and patient satisfaction with medical services, including adherence to patient rights [10, 13, 14].

As shown by the literature on the subject, not enough studies exist that simultaneously address the analysis of the knowledge of the rights and responsibilities of patients receiving various institutional forms of healthcare [15].

Numerous studies show that ED employees are exposed to various forms of aggression from patients, as well as people accompanying the patients. Another noteworthy dangerous aspect of working in the ED is the presence of intoxicated people [16, 17]. Such a state of affairs does affect the proper functioning of the ED, and consequently also the adherence to patient rights by the medical personnel. However, it should be noted that the aforementioned factors should not and cannot negatively affect the medical personnel's adherence to patient rights.

The study conducted in 2017 by Czajkowska et al. [18] included the assessment of knowledge of patient rights among medical personnel in medical facilities. The study included a group of 901 medical professionals (doctors, nurses, midwives), and the obtained results showed a high level of knowledge of patient rights among the surveyed doctors, nurses and midwives. In turn, good knowledge of patient rights among healthcare professionals was reflected in good levels of informing patients of their rights. Statistical significance was obtained for four domains: patient right to health services ($p < 0.000001$), the right to respect for privacy and dignity of the patient ($p < 0.000001$), patient right to store valuables in the depository ($p < 0.000001$), and patient right to pastoral care ($p < 0.000001$) [17]. The above study correlates with the results of this research in the field in question. A satisfactory level of knowledge of patient rights was declared by 58% of respondents, knowledge about patient right to health services was indicated by 89% of respondents, the right to respect for privacy and dignity of the patient by 91%, patient right to store valuables in the depository by 54%, and patient right to pastoral care by 64% [18].

Maintaining confidentiality about a patient's condition, as dictated by the Hippocratic Oath, is one of the oldest cornerstones of healthcare professional practice [19]. Discussing patient information outside of the workplace is considered a breach of confidentiality in rooms with general access, clinics, and waiting rooms in the ED [20]. Such practices, however, may simply be habitual rather than intentional, as research suggests [21]. In a 2013 study conducted by Beltran-Aroca et al. [22] in a Spanish hospital, situations were recorded in which professional discretion was violated by the medical personnel, including doctors, nurses, medical caregivers or orderlies. The obtained results enabled the establishment of the "confidentiality violation

rate", which averaged 1 violation per 62.5 working hours. As for the typology of the observed violations, the most common (54.6%) were related to consultation and/or disclosure of clinical and/or personal data to medical personnel not involved in the clinical care of the patient, as well as to people outside the hospital. In terms of their severity, serious violations were the most common, accounting for 46.7% of all incidents. Most of the reported incidents were observed in public places (37.9%), such as corridors, elevators, the cafeteria, stairs and locker rooms. Disclosure of patient information to unauthorized persons occurred most frequently in the internal medicine department and the emergency department [22]. In a similar study, Karasneh et al. [23] showed that doctors from various departments lacked sufficient knowledge about many aspects of patient confidentiality. Half of the participating doctors did not know whether confidentiality should be protected also after a patient's death.

The doctors participating in the study (17%) reported storing patient data on their private computers. Lack of sufficient knowledge may affect physicians' attitudes toward implementing patient data confidentiality practices in various clinical settings. Some physician practices have been identified as violating patient confidentiality. The authors' own research does not significantly differ from the presented results in terms of the patient right to respect for the privacy and dignity of the patient, for according to 65.30% of all respondents, this right is violated by medical personnel in their workplace.

However, disturbing remains the fact that as much as 22.60% of the respondents comply with patient rights only sometimes. This result is similar to those obtained in the research of Kiyancicek et al. [24]. Therefore, it seems reasonable for medical facilities to introduce training workshops on respecting patient rights in everyday professional practice during the personnel's period of employment. The present research shows that despite patient rights regulations having been in place for over 15 years [25], only 25.80% of the respondents (27.40% and 24.20% of nurses and paramedics respectively), had classes regarding patient rights during their education. Taking into consideration how necessary it is to increase the knowledge of medical personnel in the area of patient rights, and consequently their subsequent compliance with them in the work process, it is reasonable to introduce this topic in the educational process already at the stage of training

for all medical professions, which is reflected in the studies of other authors [26].

CONCLUSIONS

1. The study shows that the vast majority of the participating medical personnel became familiar with patient rights during their professional practice, and only one in four respondents gained this knowledge during their education.
2. Nearly 90% of respondents expressed the belief that patient rights concern all healthcare professionals, and about 80% said they always adhere to them in their daily professional work.
3. The most familiar patient right for nearly all respondents proved to be the patient right to health services, while the least familiar is the patient right to store valuables in the depository.
4. The statistical analysis conducted showed no statistically significant differences in the level of knowledge presented and behaviours declared in relation to patient rights, taking into account the division between paramedics and nurses.
5. Since a lack of sufficient knowledge among the ED medical personnel about the applicable patient rights may significantly affect their adherence to them and foster violations, the inclusion of issues regarding patient rights in the training of medical personnel is reasonable.
6. It is advised that medical facilities employing medical personnel introduce periodic training workshops regarding patient rights to increase their awareness in this area.

Limitations of the study

While interpreting the results of the present study, it is important to take into account certain limitations. These limitations include the limited number of study participants. The sample participating in the study does not represent the broader population of ED medical personnel. Based on the opinions of 124 respondents, it is possible only to present universal conclusions dedicated to the entire professional group employed there. The data for the study was obtained only from a sample consisting of a deliberately selected group of medical personnel working in the ED who consented to participate in the study. In the future, to increase representativeness and the possibility of a broader interpretation of the study results, the survey should include a larger survey sample and use more standardized research

tools, including a larger number of questions. Replicating the study will enable exploration of the role of other variables that may influence these relationships, thus deepening the understanding of the studied phenomenon.

Article information and declarations

Data availability statement

At the request of the editors.

Ethics statement

The article was developed in accordance with the journal's ethical principles.

Author contributions

BC — research concept and design, collection and/or assembly of data, data analysis and interpretation; JPC — research concept and design, data analysis and interpretation, final approval of the article; GW — collection and/or assembly of data; KB — research concept and design, collection and/or assembly of data; AC — data analysis and interpretation; MJ — data analysis and interpretation; RS — collection and/or assembly of data; DR — critical revision of the article, final approval of the article. All authors reviewed and critically revised the manuscript.

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VIA MEDICA

ORIGINAL ARTICLE

EFFECTIVENESS OF PRIMARY HEALTH CARE IN THE REPUBLIC OF KAZAKHSTAN DURING THE COVID-19 PANDEMIC AND FACTORS AFFECTING IT

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ABSTRACT

INTRODUCTION: Investigation of the performance of primary health care in Kazakhstan during the COVID--19 pandemic and analysing the factors influencing it is critical to improving healthcare in the face of global challenges. The purpose of this study was to identify and analyse the factors affecting the efficacy of primary health care in the Republic of Kazakhstan during the COVID-19 pandemic.

MATERIAL AND METHODS: The study design consisted of a two-stage data collection on primary health care in Kazakhstan during the COVID-19 pandemic, including a questionnaire survey of 10,459 participants from different regions and professional groups, and the application of complex statistical methods including correlation and regression analyses.

RESULTS: The study found that nurses' competence was most strongly influenced by interactions with physicians and knowledge of clinical guidelines in an epidemic setting. Statistically significant criteria such as prompt training ($r = 0.081$) and regular professional development (PD) ($r = 0.189$) showed no direct relationship with competence. General practitioners' work during the pandemic included prompt training, provision of medicines ($r = 0.519$), and preventive outreach ($r = 0.427$). Competence of doctors and nurses was correlated ($r = 0.576$) with pandemic preparedness ($r = 0.497$) and effective health staff communication ($r = 0.448$).

CONCLUSIONS: Organisational management effectiveness was related to the communication skills of managers and adequate resourcing of the clinic, where besides staff competence ($r = 0.494$), prompt provision of medicines and equipment ($r = 0.759$) played a significant role. Practical significance lies in the possibility of using the findings of this study to improve the efficiency of organisational work of primary healthcare institutions in Kazakhstan during pandemic and post-pandemic conditions.

KEYWORDS: coronavirus; health workers; survey; pandemic; professional development

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INTRODUCTION

Against the backdrop of the global epidemic of COVID-19, the effectiveness of primary health care (PHC) has come under increasing scrutiny and re-search, especially in the context of its delivery in different countries. The Republic of Kazakhstan, like many other countries, has faced the challenges presented by the COVID-19 pandemic, which has led to

the need to assess and optimise the effectiveness of PHC. In this context, there is an increase in ambulance calls, funding problems, and a decrease in the number of elective surgeries, which affects the overall healthcare situation. Thus, according to Omar and Stepkina [1] observed a considerable increase in the number of emergency ambulance calls in Almaty region, Kazakhstan, for the period from January to December 2020. At the beginning of the accounting period, in the first quarter of 2020, the number of recorded ambulance calls was 217,729. However, by the fourth quarter of 2020, that number had risen to 733,003. This increase of more than two and a half times emphasises the significant growth in the need for emergency medical services in the region. This growth could be conditioned by a variety of factors, including population growth, changes in the healthcare system, or possibly the impact of global health-saving events such as the COVID-19 pandemic, which had a considerable impact on the global healthcare system in 2020. Apart from the data provided by Omar and Stepkina, it is worth mentioning the study conducted by Sagatkali et al. [2]. This study represents a meaningful contribution to understanding the magnitude and impact of the epidemic sweeping many regions of the world in 2021. According to the findings of this study, in October 2021, at the peak of the epidemic, there were about 1 million 15 thousand cases in the region in question, which is a considerable figure. Furthermore, the same study identified 12.053 deaths, highlighting the gravity of the situation and the significance of adequate responses to healthcare crises.

Mukhamedyarova et al. [3] pointed out that at that time the system of financing emergency care failed to fulfil its tasks, which worsened the quality and speed of PHC, but staffing and general training of specialists were not considered. Therewith, the problems were observed not only at the pre-hospital stage. In their literature review, Yerniyazov and Aringazina [4] cite data that during the pandemic the number of elective surgical interventions sharply decreased, which could substantially affect the prognosis of people with both benign and malignant neoplasms, but there was no survey among staff about the difficulty of performing elective interventions at that time. According to Adilbekov et al. [5], the mortality from stroke increased by 30%, without specifying the reasons for this increase, which may be related to the deterioration of staff work due to

massive loads and the lack of proper coordination between different departments of hospitals. This situation, however, was observed not only in Kazakhstan but also in other countries [6]. That is why the present study aims at an in-depth analysis of critical aspects including organisational measures, quality of care, training, and education of health personnel.

One of the objectives of this paper was to analyse the effectiveness of PHC in the Republic of Kazakhstan during the COVID-19 pandemic and to identify the factors that have the greatest impact on this effectiveness. Another objective of this study was to provide valuable practical and theoretical findings that can serve as a basis for developing strategies to improve the PHC system, increase its adaptability to new challenges, and effectively respond to future public health emergencies and infectious disease outbreaks in the Republic of Kazakhstan.

MATERIAL AND METHODS
Study design
The present study to assess the organisational performance of primary health care in the COVID-19 pandemic was conducted in 2 phases. The first phase of data collection was conducted in 2022 during the COVID-19 pandemic and the second phase was conducted in 2023 after the quarantine measures for the disease were lifted. Two hypotheses were used:

1. Null hypothesis (H0): The COVID-19 pandemic had no significant impact on PHC performance in the Republic of Kazakhstan. This means that any observed changes in PHC performance can be attributed to random fluctuations or other factors not directly related to the pandemic.

2. Alternative hypothesis (H1): The COVID-19 pandemic had a significant impact on PHC performance in the Republic of Kazakhstan. This suggests that observed changes in PHC performance may be directly related to the impact of the pandemic, including factors such as changing market conditions, supply problems, changes in consumer demand, and government responses to the crisis.

Study sample and participants
The study included 2,252 heads of polyclinics from 17 regions of the republic at the level of cities and districts, 2,595 general practitioners (therapists), and 5,612 nurses in three age categories: 18–39 years,

40–60 years, and above 60 years. The sample was formed according to the method of continuous research among all employees of primary health care in the mentioned regions.

Data collection

The materials were primary data obtained from a questionnaire survey of respondents. Questionnaires were developed and adapted for three groups of respondents — polyclinic managers, doctors, and nurses. A questionnaire survey is a valuable data collection tool to obtain information on respondents' views, opinions, and experiences regarding the performance of the PHC system during the COVID-19 pandemic. The questionnaires were designed to consider the specific needs and perspectives of each of these groups of respondents, which makes the data obtained more representative and informative. The questionnaire responses were collected using a Likert-type scale, which allowed researchers to measure the subjective beliefs and experiences of healthcare workers. Participants were asked to rate various aspects of primary healthcare performance and influencing factors on a 5-point ordinal scale, with 1 denoting "strongly disagree" and 5 denoting "strongly agree."

Statistical analysis

A comprehensive array of statistical techniques was utilised for data analysis. Descriptive statistics, including frequency distributions, percentages, measures of central tendency, and dispersion, were calculated to summarise both categorical and continuous variables. For inferential statistics, the study employed several methods. In order to identify significant correlations between demographic characteristics and other facets of healthcare performance, the Chi-square test of Independence was utilised to investigate links between categorical variables, such as age groups and educational attainment. In order to evaluate the direction and strength of linear relationships between continuous variables, such as those between years of experience and competence scores, the Pearson correlation coefficient was used. Both paired and independent samples Students' t-tests were used to evaluate changes in scores over time and to compare mean scores between groups. To compare means across numerous groups at once, Analysis of Variance (ANOVA) was utilised. Statistical processing of the material was conducted using the licensed version of the IBM SPSS 26 package. The critical level of significance for testing statistical hypotheses was taken as 0.05.

Regression and factor analysis

Regression and factor analyses were performed after the data was checked to make sure it complied with the parametric methods' presumptions. Initially, the Shapiro–Wilk test and other graphical (Q-Q plots and histograms) techniques were used to evaluate the normality of the dependent variables. Although there were a few small deviations from normalcy, the central limit theorem could be relied upon because of the huge sample size (n > 10.000). This theorem states when a large enough sample size is taken from a population, the distribution of the sample means will be approximately normally distributed, regardless of the original population's distribution. The Kaiser–Meyer–Olkin (KMO) measure of sample adequacy was used to evaluate the acceptability of the data for factor analysis. The result was a value of 0.89, which was higher than the suggested threshold of 0.6. Factor analysis was warranted since Bartlett's test of sphericity revealed a significant result (p < 0.001), proving that the correlation matrix was not an identity matrix.

Regression analysis was used in which R is the correlation between the observed value of the dependent variable and the predicted model in the three age categories. The indicator R-squared (R^2) is called the coefficient of multiple determination and characterises the proportion of variation in the dependent variable explained by the model. R^2 is usually interpreted as the coefficient of determination and can range from 0 to 1. The closer the R^2 value is to 1, the better the model explains the variability of the dependent variable. By keeping the predicted values unstandardised and making a correlation between the dependent variable and the predicted variable, the values were adjusted, and, like R^2 showed the proportion of variability explained by the model. When the regression was constructed on the samples, it was found that they were chosen correctly, as evidenced by the R and R^2 values, and the model in this case had a great level of significance of the criteria. The obtained results of regression analysis helped to evaluate the impact of the criterion "Professional competence of the clinic staff" for effective management of the organisation's performance in terms of predicting this criterion.

The next stage of this study was to conduct factor analysis to identify the most significant

Table 1. Chi-square tests

	Value	St.St.	Asymptotic significance (2-way)	Monte Carlo significance (2-way)			Monte Carlo significance (1-way)		
				Value	99% confidence interval		Value	99% confidence interval	
					Bottom	Upper		Bottom	Upper
Pearson chi-square	64.429a ⁻	32	0.001	0.001b _	0	0.001			
Likelihood ratios	72.249	32	0	0b –	0	0			
Fisher's exact test	66.865			0b –	0	0			
Line-to-linear connection	15.783 s	1	0	0b –	0	0	0b	0	0
Number of valid observations	2595								

Source: compiled by the authors of this study

factors affecting the criterion. The analysis used the principal component method for factor extraction, with Varimax rotation and Kaiser normalisation. As is well known, the purpose of factor analysis is to find such complex factors that explain the observed relationships between the available variables as fully as possible. Many eigenfactors with values greater than one were first found by the study. However, the researchers concentrated on the most important components for interpretation. For instance, only the top three eigenfactors from the examination of clinic managers' responses were chosen for the further examination out of the six that were found. The researchers named each component in accordance with the recurring themes among the highly loaded variables, and they interpreted these factors based on the loadings of different criteria. Thus, this approach helped to obtain reliable results and form valid conclusions about the factors of the effectiveness of the organisation of PHC during the pandemic.

RESULTS

A comparative analysis of the answers to the questions among the three groups revealed some differences in the priorities and significance of the issues of proper organisation of work during the pandemic, and attitudes towards preventive approaches during the peak of infectious disease incidence.

The first question of this study was to determine the age composition of health personnel living in different regions of the country during the pandemic. For this, it was necessary to establish whether the selected samples drawn from the survey of respondents had a normal distribution. This, in turn, was needed to determine the possibility of conduct-ing adequate statistical research in this perspective, with this category of people. Next, conditional table, Chi-square, Pearson's test, and Spearman's correlation were used to determine the number of respondents in the mentioned above age categories. It turned out that the correctness of the Chi-square test acceptable for the calculations ($p \leq 0.001$) is significant and hence the null hypothesis (H0) of the independence of variables is rejected. The region of residence of the respondents and their age were dependent on each other. For managers, an increase in the number of young respondents aged 18–39 years old was noted (here the exception was such regions as Turkestan, Aktobe, Pavlodar, East-Kazakhstan region, and Astana). It was accompanied by a continuing decline in the number of older professionals aged over 60 years old (the exception was East-Kazakhstan, West-Kazakhstan, North-Kazakhstan, Aktobe, Zhambyl Pavlodar, and Kostanay regions).

For general practitioners, an analogous study also showed a trend towards "youthification" of specialists in this profile (exceptions were Turkestan, Aktobe, West Kazakhstan, and North Kazakhstan) and a continuing decline in the number of older specialists (exceptions were Aktobe, Zhambyl region, and Astana and Shymkent) (Tab. 1).

Considering the standardised residuals for the individual fields of the contingent population table, it can be concluded that this significance is mainly determined by the fields in which the variable of respondents works. That is, the hypothesis about the decrease in the number of elderly respondents among general practitioners took place in all regions of the Republic of Kazakhstan. For polyclinic nurse respondents, according to the comparison of means, and t-test for independent samples, there was no significant dependence on age composition

Table 2. Summary for model [b]

Model	R	R^2	Adjusted R^2	Standard error of estimate	Change statistics		St.St.1	Art.St.2	Meaning Change F
					Change R^2	Change F			
1	0.634a –	0.402	0.388	0.432	0.402	27.726	42	1730	0

Note: (a) Predictors: (constant), COVID-19 information coverage, length of staff time, interaction with the Department of Healthcare Management, level of polyclinic, adequate provision of transportation means, respondent's region of residence, doctors' opinion on procurement of medicines, respondent's gender, involvement in handling patient complaints, use of Standard Operating Procedures (SOPs) in staff work, doctor's competence, respondent's education, regular qualification improvement (QI), development of benefits for patients of the polyclinic, use of forecasting in work, Individual Development Plan (IDP) developed, prompt problem solving, age of the respondent, provision of medicines for COVID-19, staff interaction, regular updating of knowledge of regulations, sufficient provision of outpatient clinic equipment, involvement in IDP development, prompt supply of medicines, speed of COVID-19 detection, prompt training of nurses and doctors for QI, readiness to work under COVID-19, organisation of patient flow, ability to make proposals on volumes and types of required medicines and medical devices, organisation of management under COVID-19, interaction between doctors and nurses, duration of work in the polyclinic, competence of nurses, created conditions for QI, the attached population is sufficiently covered by the information campaign on COVID-19 prevention, sufficient provision of transport and equipment for COVID-19, the total record of service of the respondent; b) dependent variable: the efficiency of the organisation
Source: compiled by the authors of this study

Table 3. Model ANOVA[a]

Model		Sum of squares	St.St.	Middle square	F	Significance
1	Regression	217.353	42	5.175	27.726	0b –
	Remainder	322.909	2205	0.187		
	Total	540.262	1772			

Note: (a) dependent variable: organisational management performance
Source: compiled by the authors of this study

in 17 regions of the Republic of Kazakhstan (p = 0.766, CI 95%). However, the expected numbers, as well as the age composition of the nurse respondents, differed from the age composition prevailing among the medical staff. There was also a tendency to "rejuvenate" the staff, but at a slower pace, the ratio of the age structure of 18-39 years and 40–60 years was almost 1.1:1 (51.3% and 45.9%, respectively). Furthermore, some areas predicted an increase in older respondents rather than younger respondents. These include such regions as Turkestan, East Kazakhstan, West Kazakhstan, North Kazakhstan, Almaty, and Karaganda. Next, the task was to predict the criteria under study among the executive respondents using regression analysis, where R amounted to 0.634, indicating a fairly strong correlation (Tab. 2).

The values were adjusted and like R^2. As there are no precise requirements for this indicator, the obtained value of R^2 — 0.402 — was considered to be an agreed value in this case. Table 3 prompts strong conclusions about this model. It tests the hypothesis of equality R^2 = 0, and therefore a high level of significance of the criterion is required (p ≤ 0.001).

Table 4 shows the prediction for the variables, *i.e.*, the beta weights show how much "Y" will change when "X" changes by 1 unit. As in the example above, a 1 unit change in organisational management effectiveness would change general

practitioner's competence by 0.169 and effective medical staff interaction by 0.14 (p ≤ 0.001). If the sign of correlation is negative, an inverse relationship is observed, which means that organisational management effectiveness will increase if the number of male managers also increases by 0.066 units (p ≤ 0.01). Thus, it was possible to obtain a prediction on these criteria for clinic managers.

Thus, when the regression was constructed on the samples of this study, it was found that the samples in this study were chosen correctly as evidenced by the R and R-squared values, and the model in this case has a high level of criterion significance. The obtained results of regression analysis helped to evaluate the impact of the criterion "Professional competence of clinic staff" for effective management of the organisation's performance in terms of predicting this criterion. The next stage of this study was to perform a factor analysis to determine the key factors affecting the criterion "Organisational effectiveness for respondents, clinic managers".

Table 5 shows that 6 eigenfactors have values greater than one. The three most significant factors were selected for analysis. When deciphering the table for the first component, the most significant criteria were as follows: "Sufficient provision of transport and equipment to the clinic" (r = 0.759), "Prompt delivery and provision of medicines" (r = 0.671), "Current human resources of the organisation

Table 4. The coefficients or beta weights of each independent variable separately (a)							
Model	Non-standard coefficient		Standard coefficient	T	Value	95% confidence interval for B	
	B	Standard error	Beta			Bottom	Upper
(Constant)	0.376	0.101		3.707	0	0.177	0.574
Region of residence of the respondent	−0.004	0.002	−0.036	−1.85	0.064	−0.008	0
Polyclinic level	0.025	0.022	0.022	1.108	0.268	−0.019	0.069
Gender of respondent	−0.066	0.031	−0.044	−2.15	0.032	−0.125	−0.006
Age of respondent	0.03	0.026	0.03	1.139	0.255	−0.021	0.08
Record of service as a manager	0.009	0.009	0.027	1.062	0.288	−0.008	0.027
Total record of service	−0.037	0.015	−0.081	−2.45	0.014	−0.066	−0.007
Education	−0.014	0.012	−0.025	−1.162	0.245	−0.037	0.01
Duration of operation	0.005	0.013	0.012	0.363	0.717	−0.021	0.03
Duration of work in the polyclinic	0.009	0.01	0.026	0.916	0.36	−0.011	0.029
Physician competence	0.169	0.024	0.19	6.989	0	0.122	0.217
Competence of the nurse	0.019	0.025	0.022	0.779	0.436	−0.029	0.068
Interaction between doctor and nurse	−0.03	0.025	−0.034	−1.199	0.231	−0.080	0.019
Interaction of outpatient clinic staff	0.14	0.027	0.143	5.168	0	0.087	0.193
Prompt resolution of problems	0.063	0.021	0.073	3.03	0.002	0.022	0.103
Liaising with the Healthcare Authority	0.057	0.016	0.097	3.644	0	0.026	0.087
Readiness to work during COVID-19	−0.021	0.02	−0.028	−1.042	0.297	−0.059	0.018
Coordinating medicines supplies with doctors	−0.064	0.019	−0.097	−3.394	0.001	−0.101	−0.027
Consideration of doctors' opinions when purchasing medicines	0.082	0.025	0.082	3.223	0.001	0.032	0.132
Opportunity to make suggestions	0.006	0.015	0.012	0.419	0.675	−0.023	0.035
Use of forecasting in work	−0.005	0.014	-0.009	−0.343	0.732	−0.032	0.023
Prompt supply of medicines	−0.003	0.017	−0.005	−0.19	0.85	−0.036	0.03
Prompt supply of medicines under COVID-19	−0.012	0.022	−0.014	−0.536	0.592	−0.054	0.031
Sufficient equipment	0.019	0.016	0.03	1.225	0.221	−0.012	0.05
Sufficient means of transport at the polyclinic	0.002	0.014	0.004	0.13	0.897	-0.025	0.028
Sufficient equipment and transport under COVID-19	−0.01	0.019	−0.016	−0.528	0.598	−0.047	0.027
Detection rate under COVID-19	0.078	0.024	0.083	3.195	0.001	0.03	0.126
Use of SOPs	−0.004	0.019	−0.004	−0.203	0.839	−0.04	0.033
Organisation of patient flow segregation	0.047	0.022	0.057	2.112	0.035	0.003	0.091
Interaction between doctors and personnel	0.027	0.025	0.028	1.094	0.274	-0.022	0.076
Involvement in the resolution of patient complaints	−0.01	0.008	−0.028	−1.256	0.209	−0.026	0.006
Organisation of management under COVID-19	0.101	0.025	0.113	4.07	0	0.052	0.15
Involvement in the IDP development	0.008	0.014	0.015	0.611	0.541	−0.018	0.035
Conditions for QI are good	0.006	0.013	0.012	0.412	0.68	−0.021	0.032
Regular completion of QI	0.008	0.018	0.012	0.436	0.663	−0.027	0.043
Regular updating of knowledge of regulations	−0.048	0.019	−0.064	−2.554	0.011	−0.086	−0.011
Prompt QI by doctors and nurses	0.033	0.024	0.038	1.393	0.164	−0.013	0.079
Participation in infection prevention awareness	0.004	0.017	0.007	0.238	0.812	−0.03	0.038
Informing the population about the benefits	0.013	0.018	0.018	0.697	0.486	−0.023	0.048

Note: (a) dependent variable: organisational management performance
Source: compiled by the authors of this study

Table 5. Matrix of rotated components (a, b)

| | Raw materials | | | | | | Recalculated | | | | | |
| | Component | | | | | | Component | | | | | |
	1	2	3	4	5	6	1	2	3	4	5	6
Region of residence		0.842		0.628		4.687		0.175		0.131		0.974
Polyclinic level						-0.083						-0.167
Gender			0.089						0.25			
Age			0.364	-0.062					0.649	-0.11		
Manager's record of service		0.254	1.324	-0.397				0.159	0.829	-0.249		
Total record of service			1	-0.173					0.83	-0.144		
Education	0.302	-0.311	-0.167	-0.153			0.302	-0.312	-0.168	-0.154		
Duration of operation		-0.144	1.24	0.141	-0.174			-0.102	0.88	0.1	-0.123	
Duration of work in the polyclinic			1.274	0.546	-0.257				0.822	0.352	-0.166	
Physician competence	0.203						0.405					
Competence of nurses	0.256						0.494					
Interaction between doctors and nurses	0.221						0.458					
Personnel interaction	0.167						0.403					
Prompt resolution of problems	0.243						0.457					
Interaction with the Healthcare Authority		0.622		0.180				0.667		0.193		
Readiness to work during COVID-19	0.396						0.614					
Coordination of medicines supply with doctors		0.644						0.76				
Consideration of the opinion of doctors on the purchase of medicines and medical equipment	0.104	0.163		-0.055			0.223	0.352		-0.119		
Manager's suggestions on the volume and types of medicinal products		0.853						0.83				
Use of forecasting of consumption of medicines and medical devices	0.125	0.719					0.124	0.717				
Prompt delivery of medicines to the polyclinic	0.482						0.671					
Sufficient provision of medicines under COVID-19	0.36	0.059					0.615	0.101				
Sufficient equipment	0.523						0.659					
Sufficient means of transport at the polyclinics	0.755						0.729					
Provision of transport and equipment under COVID-19	0.611						0.759					

Table 5. (cont.) Matrix of rotated components (a, b)

	Raw materials Component						Recalculated Component					
	1	2	3	4	5	6	1	2	3	4	5	6
COVID-19 detection rate	0.221						0.509					
Use of SOPs	0.161						0.273					
Organisation of patient flow segregation	0.322						0.579					
Interaction between doctors and staff is good	0.208						0.477					
Involvement in the resolution of patient complaints		0.515		0.322	1.367			0.335		0.21	0.889	
Organisation of management under COVID-19	0.285						0.584					
IDP development	0.519			0.172	0.094		0.595			0.197	0.108	
Conditions for QI are good		0.773		0.661	0.141			0.647		0.554	0.118	
Regular completion of QI	0.293	0.085	−0.097	0.158			0.441	0.128	−0.146	0.237		
Regular updating of knowledge of regulations	0.247	0.183					0.401	0.298				
Prompt QI by doctors and nurses	0.269						0.536					
Development of measures to inform the population about the prevention of infection	0.117	0.658			0.165		0.132	0.741			0.186	
Development of measures to inform the population about the preferential provision of medicinal products	0.237	0.334			0.132		0.324	0.458			0.181	
The population is sufficiently covered with information about COVID-19	0.065						0.107					

Note: Factor extraction method: principal component method. Rotation method: Varimax with Kaiser normalisation. a) rotation converges in 5 iterations; b) only observations for which effective organisational management = 1 yes are used in the analysis phase.
Source: compiled by the authors of this study

ensure readiness to work under COVID-19 pandemic" (r = 0. 614), "Organisation of patient flow" (r = 0.579), "Prompt response of clinic staff to detection of contact/infectious patient" (r = 0.509), "Prompt completion of qualification improvement (QI) training by doctors" (r = 0.536), "Creation of conditions for staff training" (r = 0.537), "Knowledge of regulations by clinic staff" (r = 0.406), "Competence of doctor" (r = 0.405), "Competence of nurse" (r = 0.494). This data was considered as the opinion of clinic managers on the need for adequate provision of trained staff, medicines, and medical equipment. Therefore, this component was named "Provision of health facility with personnel and medical equipment".

Next, using factor analysis, the factors affecting the second component were identified. The most significant criteria affecting the effectiveness of the organisation's management were: "Regularly approved and/or took part in the development of measures to inform the population about the conditions of medical care and disease prevention" (r = 0.741), "Systematically developed/organised activities to inform the population about the possibility of preferential provision of patients with dynamic monitoring" (r = 0.458), "Conditions for QI training were created" (r = 0.647), "Schemes/methods of forecasting costs for medicines and medical devices were used, considering the dynamics of morbidity in the region" (r = 0.717), "Ability to make proposals on volumes and types of necessary medicines and medical devices" (r = 0.83), "Coordinated volumes and types of medicines with doctors of the outpatient clinic when placing an order" (r = 0.76), "Interacted well with controlling organisations" (Healthcare Authority, Ministry of Healthcare of the Republic of Kazakhstan) (r = 0.667). This component is titled "The role of communication skills of an organisation leader in organisational performance." In the third component, the significant criteria were mainly as follows: "Supervisor work experience" (r = 0.83), "Supervisor age" (r = 0.649), and "Record of service in primary care" (r = 0.88). This component was labelled as "Supervisor experience". Thus, some attitudes of the respondent clinic managers were explained in the factor analysis. For the effective work of the head of a medical facility (polyclinic), first of all, the clinic must be provided with trained competent staff, sufficient equipment and medicines, a low rate of personnel turnover, communication skills, the openness of the head to

innovations, their experience and record of service in primary health care institutions.

In terms of general practitioners, a critical issue was to sample their competence, ways to improve it, and identify factors affecting it. For this, by calculating paired samples, the study managed to determine the degree of correlation in the samples and its significance. The most commonly used method of statistical analysis involves comparing the averages of distinct independent samples. If there is a difference in the mean values, two independent samples were compared using Student's t-test. In addition, the significance of differences between the selected samples was determined. When determining impact, samples such as "Age", "Doctor's position", and "Experience" had no impact on "General practitioners' competence" ($p \geq 0.05$). Samples such as "Organisational management effectiveness", "Nurse competence", "Willingness to work under difficult conditions," and "Doctor-nurse interaction effectiveness" had a statistically significant effect on "General practitioners' competence" ($p \leq 0.05$).

According to Student's t-test for paired samples, "Competence of doctors and nurses" correlated with each other (r = 0.576; $p < 0.001$), "Competence of doctors" correlated with the criterion of "Readiness to work under COVID-19 conditions" (r = 0.497; $p < 0.001$), with the "Efficiency of interaction between doctors and nurses" (r = 0.448; $p < 0.001$), "Prompt QI completion by nurses and doctors" (r = 0.354; $p < 0.001$). A moderate degree of correlation was noted between the criteria "Use of Standard Operating Procedures (SOPs) in general practitioners' work" (r = 0.101; $p < 0.05$), and "Agreeing on a work plan for infection prevention" (r = 0.183; $p \geq 0.5$). There was no correlation between the competence of general practitioners and their involvement in complaints, the region of residence of the respondent, and the duration of work in the clinic (r = 0.024; $p < 0.05$) (Tab. 6).

The paired samples test in this case confirmed a significant difference between the selected pairs of samples. This study should also exclude the null hypothesis and take the alternative hypothesis as the basis for the hypothesis that is supported by differences and effects. The above data indicate that the readiness of general practitioners to work under the conditions of a pandemic was influenced to a greater extent by the effective work of the organisation, sufficient medical equipment and medical devices, medicines, informing the population about

Table 6. Paired sample correlations		N	Correlation
Pair 1	Region of residence & doctors' competence	2010	0.036
Pair 2	Doctors' competence & record of service in the polyclinic	2012	0.02
Pair 3	Doctors' competence & nurses' competence	2012	0.576
Pair 4	Doctors' competence & Readiness to work under COVID-19	2012	0.497
Pair 5	Competence and interaction between doctors and nurses	2012	0.448
Pair 6	Doctors' competence & Knowledge of regulations	2012	0.314
Pair 7	Prompt QI completion by nurses & doctors' competence	2012	0.354
Pair 8	Doctors' competence & the use of SOPs	2012	0.101
Pair 9	Participation in handling patients' complaints & doctors' competence	2012	0.024

Source: compiled by the authors of this study

Table 7. Summary for model (b)				
Model	R	R^2	Adjusted R^2	Standard estimate error
1	0.668a⁻	0.446	0.443	0.438

Note: (a) predictors: (constant), use of medicine consumption prediction, total years of experience, use of SOPs, nurses' competence, COVID-19 detection rate, infection prevention measures in the population, organisational management performance, willingness to work under COVID-19, specialist length of service; (b) dependent variable: doctors' competence.
Source: compiled by the authors of this study

Table 8. ANOVA (a)					
Model	Sum of squares	St.St.	Average area	F	Value
Regression	308.787	10	30.879	161.123	0b⁻
Residue	383.484	2586	0.192		
Total	692.27	2596			

Note: (a) dependent variable: doctors' competence; (b) predictors: (constant), use of medicines consumption prediction, total years of experience, use of SOPs in work, nurses' competence, infection detection rate, infection prevention measures, organisational management performance, willingness to work under COVID-19 conditions, doctor' record of service.
Source: compiled by the authors of this study

coronavirus infection, preventive work in the context of the spread of infection, and management of patient flow. There was no correlation with the release of additional transport in pandemic conditions. General practitioners' use of SOPs and their readiness to work under COVID-19 were not statistically significant ($p \geq 0.05$). Upon constructing the prediction of the criteria under study among the respondents, regression analysis was used in which R is 0.668, i.e., with those on which the regression line passes, indicating a fairly strong correlation (Tab. 7).

The values will be adjusted and with them the R^2. The resulting R^2 value of 0.446 will be considered consistent in this case. Table 8 prompts strong conclusions about the model formed in the study, a high level of significance of the criterion is required ($p \leq 0.001$).

If "General practitioners' competence" (dependent variable) changes by 1 unit, the variable "Willingness to work under COVID-19 conditions" will change by 0.096, and "Organisation management effectiveness" will also change "General practitioners' competence" by 0.117. An inverse relationship would mean that if the "General practitioners' competence" increases, the "Experience of the polyclinic doctor" will increase by 0.037 units. Thus, the prediction of these criteria for general practitioners was obtained (Tab. 9).

The next stage of this study was to conduct a factor analysis to determine the key factors affecting the criterion "Organisational effectiveness" for general practitioners-respondents.

The table shows that 12 eigenfactors have values greater than one. The five most significant factors were selected for analysis. When deciphering the table of the rotated matrix of components for the first component, the most significant criteria were as follows: "Participation in activities to inform the population about the conditions of medical care and disease prevention" ($r = 0.872$), "Polyclinic has created conditions for QI or training, seminars related to preparedness to work under COVID-19 conditions" ($r = 0.814$), "Nurses of the polyclinic take prompt and sufficient QI training" ($r = 0.806$), "Regularity of QI training" ($r = 0.749$), "System of management and organisation of medical care in the polyclinic allows ensuring readiness to work under COVID-19 conditions" ($r = 0.729$), "Use of SOPs in work" ($r = 0.717$), "Participation in the development of Individual Development Plans (IDP)" ($r = 0.709$), "Patient flow management" ($r = 0.696$), "Infection detection rate" ($r = 0.691$), "Adequate provision of the facility with medical transport during COVID-19" ($r = 0.677$), "Adequate provision of medical

Table 9. Coefficients (a)

Model	Non-standard coefficient		Standard coefficient	T	Value
	B	Standard error	Beta		
(Constant)	0.306	0.036		8.441	0
Professional experience	−0.037	0.017	−0.107	−2.185	0.029
Total record of service	0.041	0.017	0.119	2.442	0.015
Effectiveness of the organisation's management	0.117	0.015	0.162	7.72	0
Nurses' competence	0.302	0.017	0.357	17.887	0
Willingness to work under COVID-19	0.096	0.014	0.151	6.713	0
Preventive work under COVID-19	0.045	0.015	0.062	2.933	0.003
Infection detection rate	0.083	0.018	0.087	4.498	0
Use of SOPs in the workplace	−0.02	0.009	−0.039	−2.209	0.027
Infection prevention measures	0.044	0.014	0.063	3.258	0.001
Medicines consumption forecasting	0.023	0.011	0.038	1.996	0.046

Note: (a) Dependent variable: doctors' competence
Source: compiled by the authors of this study

equipment to the facility" (r = 0.638), "Prompt provision of medicines" (r = 0.523), "Adequate provision of medical equipment to the facility" (r = 0.638), "Provision of medicines under COVID-19 conditions" (r = 0.622). Apart from these criteria in this component, the following criteria had moderate correlation with a negative sign: "Total record of service of the specialist" (r= −0.404), "Duration of work" (r= −0.319). This data was considered as "General practitioners' perception" that a specialist's length of service and length of time working in primary care was, in their opinion, essential to the effective performance of the organisation. Therefore, this component will be referred to as competent staffing of the health facility.

Next, using factor analysis, the factors affecting the second component were identified. The most significant criteria affecting the competence of doctors were as follows: "Availability of sufficient medical equipment and transport during the pandemic" (r = 0.67), "Management and separation of patient flow during the pandemic" (r = 0.699, r = 0.648), "Prompt provision of medicines and supplies to the treatment and diagnostic facility" (r = 0.663), "Participation in activities to inform the population about the conditions of medical care and disease prevention" (r = 0.654). Furthermore, such criteria as "Development of IDP for each specialist of the clinic," "Regular updating of knowledge about new versions of clinical protocols and changes in regulations," and "Creation of conditions in the clinic for QI training" were quite strongly correlated with

each other and were significant. This component was named "Ways to improve the organisation of diagnostic and treatment work of primary care physicians."

To identify the factors affecting the work of general practitioners during the pandemic, the third component was considered, in which the significant criteria were as follows: "Prompt provision of medicines during the pandemic" (r = 0.519), "Sufficient diagnostic and therapeutic equipment" (r = 0.529), "Preventive work conducted among the population during the pandemic" (r = 0.427), "Separation of patient flow during the pandemic" (r = 0.598), "Preventive work conducted among the population during the pandemic" (r = 0.427), "Separation of patient flow during the epidemic" (r = 0.598), "Regular training, seminars, master classes" (r = 0.506), "Informing about changes in the regulations" (r = 0.525), "IDP development" (r = 0.623). This component was named "Key steps in overcoming the epidemic." Thus, the factor analysis explained some positions of doctors-respondents of polyclinics of general practice serving the population during epidemics. In other words, for the effective work of a medical institution (polyclinic), it is important to provide the polyclinic with uninterrupted prompt supply of medicines, transport, and medical equipment, regular training of both general practitioners and nurses of these polyclinics, knowledge of regulations, and their new wordings. Also important for general practitioners was experience and length of service in PHC, and the low rate of

personnel turnover among specialists. The work of general practitioners during the pandemic, according to the respondents, was prompt training in COVID-19, adequate supply of anti-COVID-19 medicines, segregation of patient flow, and preventive work among the population during the pandemic.

To establish whether there is a relationship between several variables such as age of respondents, education, and nursing competence level among nurses, conditional table, Chi-square, Pearson's test, and Spearman's correlation was used. 56.4% of respondents had secondary education, 37% had higher education, 5.8% had a bachelor's degree, and 0.8% had a master's degree. Among the respondents aged 18–39 years, almost 25% of the nurses had secondary education and the expected number was higher than the observed number, indicating that the variables were mutually dependent. With higher education – the expected number decreased significantly. Considering the standardised residuals in the individual fields of the randomness table for forecasting, it can be concluded that this significance is mainly determined by the fields in which the variable "Education" has the value "Average". This value is elevated among respondents aged 18–39 years and decreased among respondents aged 40–60 years, 60 years and older. In the age category 40–60 years, on the contrary, the number of respondents with higher education, bachelor, and masters increases. Proceeding from the above, it can be assumed that among the respondents among young nurses aged 18–39 years old, the number of professionals with "technical" education will decrease, and professionals with higher education with bachelor's and master's degrees, on the contrary, will increase.

During the COVID-19 pandemic, according to the nurse respondents, the "Nurses' competence" criterion identified fairly significant Pearson correlation values with "Organisational effectiveness as well as Nurses' competence and Doctors' and nurses' effectiveness in a pandemic" as well as their "Willingness to work under COVID-19 conditions." It can be concluded that the null hypothesis should be ruled out here and an alternative hypothesis that confirms those differences and effects should be adopted. At the same time, comparison criteria such as regularity of nurses' QI training and their prompt completion did not find such a connection (p ≥ 0.5). Furthermore, nurses' competence was not strongly influenced by the use of SOPs in work (r = 0.081),

regularity of QI training (r = 0.189), and the use of clinical guidelines in work (r = 0.198). Therewith, the criterion "Willingness to work under COVID-19" correlated quite strongly with the criteria "Use of clinical guidelines in nursing work" and "Regularity of QI training". As a result, it was found that the competence of nurses was more influenced by effective doctor-nurse communication, and for effective work in a pandemic setting, knowledge and use of clinical guidelines, and their prompt training were of absolute significance.

Regression analysis was used to construct the forecast based on the criteria under study, where R is 0.313, i.e., with those along which the regression line runs, indicating a fairly strong correlation (Tab. 10).

The resulting R^2 value of 0.098 was found to be appropriate for this case. Table 11 allowed strict conclusions to be drawn about the generated model, a high level of significance of the criterion was required (p ≤ 0.001).

As in this example, a 1-unit change would change the "Nurse's competence" (dependent variable) and "Willingness to work during a pandemic" by 0.271. Applying the algorithm to identify an infectious patient will also change the nurse's competence by 0.067. If the sign of correlation is negative, then there is an inverse relationship, i.e., if the "Nurses' competence" increases, the respondent's length of service will decrease by –0.07 units. Thus, the prognosis according to the criteria of this study for nurses was generated (Tab. 12).

The authors used factor analysis to determine the key factors affecting the criterion "Organisational effectiveness in nurses-respondents' performance" (Tab. 13).

The table shows that 5 eigenfactors have values greater than one. Therefore, five factors were selected for analysis. The first factor explains 45.182% of the total variance, the second explains 14.61%, and the third explains 5.22%. The principal component method was used to select factors; the programme used the Varimax rotation with Kaiser normalisation to rotate factors. Of the 5 components, 3 were the most significant.

DISCUSSION

The findings of this study are of considerable interest to assess and analyse the performance of the PHC system in Kazakhstan during the COVID-19 pandemic.

Table 10. Summary for model (b)

Model	R	R^2	Adjusted R^2	Standard error of estimate	Statistics of change				
					Changes in R-square	Changes in F	St.St 1	St. 2	Meaningful changes in F
1	0.313a –	0.098	0.097	0.425	0.098	162.604	4	5558	0

Note: (a) predictors: (constant), use of infection detection algorithm 5, use of SOP in work 5, willingness to work under COVID-19 5, knowledge of regulations 5; (b) dependent variable: nurses' competence 5

Source: compiled by the authors of this study

Table 11. ANOVA (a)

Model	Sum of squares	St.St.	Average area	F	Value
Regression	117.563	4	29.391	162.604	0b –
Residue	1082.689	5558	0.181		
Total	1200.251	5562			

Note: (a) dependent variable: nurses' competence 5; (b) predictors: (constant), use of infection detection algorithm 5, use of SOPs in work 5, willingness to work under COVID-19 5, knowledge of regulations 5

Source: compiled by the authors of this study

Table 12. Coefficients (a)

Model	Non-standard coefficient		Standard coefficient	T	Value	Correlations		
	B	Standard error	Beta			Zero order	Partially	Component
(Constant)	0.664	0.025		26.089	0			
Readiness to work under COVID-19 5	0.336	0.017	0.271	19.746	0	0.303	0.247	0.242
Knowledge of regulations 5	0.034	0.015	0.032	2.314	0.021	0.165	0.03	0.028
Use of SOPs 5	0	0.011	0	−0.022	0.982	0.08	0	0
Use of the COVID-19 detection algorithm 5	0.11	0.022	0.067	4.995	0	0.155	0.064	0.061

Note: (a) dependent variable: nurses' competence 5

Source: compiled by the authors of this study

These results not only highlight the current state of the healthcare system but also identify a range of critical aspects that need to be considered when planning and implementing strategies to improve the situation.

The first essential aspect identified in the study is the "youthification" of the personnel of polyclinic doctors. This is due to both natural demographic processes and the optimisation of personnel policy aimed at attracting young specialists. Younger staff may be more adaptable to new technologies and practices, which is a positive change. However, it should be considered that experienced doctors of pre-retirement and retirement age also play a vital role in ensuring continuity in the work of medical institutions [7]. Therefore, in the development of personnel policy, it is essential to strike a balance between attracting young specialists and retaining experienced staff, because this factor can affect the quality of treatment [8]. The creation of policies that support mentorship programmes that pair up younger healthcare workers with experienced specialists would be one way to keep a balanced workforce. Another way would be to devise retention strategies for older healthcare workers, such as roles that leverage their experience without requiring them to perform manual labour. Goyal and Ish [9] noted the high performance of young medical personnel during COVID-19, and low risk of mortality due to increased risk of becoming ill during exposure. Hassamal et al. [10] conducted a survey among medical staff on the level of stress and burnout, it was determined that personnel with long work experience had sharply expressed symptoms

Table 13. Explained total variance (a)								
Component	Initial eigenvalues			Extraction of the sum of squares of loads			Rotation of the sum of squares of loads		
	Total	% of variance	Total %	Total	% of variance	Total %	Total	% of variance	Total %
1	9.126	45.182	45.182	9.126	45.182	45.182	1.423	7.046	7.046
2	2.951	14.61	59.792	2.951	14.61	59.792	8.229	40.742	47.788
3	1.054	5.22	65.011	1.054	5.22	65.011	2.494	12.346	60.134
4	1.035	5.122	70.133	1.035	5.122	70.133	0.675	3.342	63.476
5	0.54	2.671	72.804	0.54	2.671	72.804	1.884	9.329	72.804
6	0.443	2.191	74.995						
7	0.433	2.143	77.139						
8	0.375	1.859	78.998						
9	0.334	1.652	80.649						
10	0.291	1.439	82.088						
11	0.282	1.396	83.484						
12	0.268	1.326	84.81						
13	0.243	1.202	86.012						
14	0.227	1.122	87.134						
15	0.202	1.002	88.136						
16	0.191	0.948	89.084						
17	0.185	0.915	89.998						
18	0.174	0.86	90.858						
19	0.164	0.812	91.67						
20	0.159	0.787	92.457						
21	0.142	0.701	93.158						
22	0.129	0.641	93.799						
23	0.126	0.623	94.422						
24	0.116	0.576	94.998						
25	0.098	0.488	95.486						
26	0.092	0.456	95.942						
27	0.083	0.409	96.351						
28	0.077	0.38	96.73						
29	0.072	0.356	97.086						
30	0.067	0.331	97.417						
31	0.064	0.315	97.732						
32	0.058	0.286	98.019						
33	0.054	0.266	98.285						
34	0.052	0.259	98.543						
35	0.048	0.236	98.78						
36	0.046	0.227	99.006						
37	0.045	0.221	99.227						
38	0.043	0.212	99.439						
39	0.04	0.196	99.635						
40	0.038	0.19	99.825						
41	0.035	0.175	100						

Source: compiled by the authors of this study

of depression of medium severity and psycho-emotional exhaustion, which can affect professional activity. In this study, the percentage of staff with up to 5 years of experience was about 48.5%, which correlates with the results of this study as the percentage of young nurses between 18 and 39 years was 51.3%.

Organisational management is also key to effective pandemic control [11]. Polyclinic managers note that the speed of staff response to the identification of suspected COVID-19 cases, responsiveness to ongoing tasks, and adequacy of staffing substantially affect management performance. However, they do not attach much importance to community outreach. This may be one of the reasons why some people are not sufficiently aware of coronavirus infection prevention measures [12]. It is recommended to strengthen community outreach to increase awareness and adherence to prevention recommendations. This could involve funding for community health worker programs, public health campaigns tailored to local contexts, and the integration of health education into school curricula. Apart from that, communication between different levels of healthcare providers is also very important, which underscores the need for policies that promote interdisciplinary collaboration. Teams-based care models and formal channels of regular communication between various healthcare roles (such as regular interdisciplinary case conferences or the use of integrated electronic health record systems that facilitate information sharing) would be beneficial additions to healthcare systems.

Kaye et al. [13] note the global nature of the shortage of staffing, medicines, and medical equipment in the USA during the pandemic, with costs of up to $52 billion per month, which was a massive burden on the healthcare system at that time. Proceeding from this experience, the participating managers were most likely guided by their experiences during the pandemic, which is consistent with the results of the cited study. Another significant factor is working under understaffed conditions, which was also observed in the pre-pandemic period, which substantially affected the quality of care through physical and psycho-emotional exhaustion of human resources. In their review of 7,334 articles, Iddrisu et al. [14] noted that almost 90% of nurses have post-traumatic stress disorder, depression, sleep disturbance, and general asthenia, especially in young staff due to the enormous workload.

Therefore, managers in Kazakhstan are particularly emphasising this point, as it is difficult to coordinate the work of exhausted staff in an atmosphere of increasing workload.

The preparedness of physicians to work in a pandemic also has an impact on the effectiveness of COVID-19 control [15]. Provision of necessary medical devices and medicines, informing the population and organising patient flows are significant for polyclinic therapists. However, SOPs and algorithms according to COVID-19 do not have a statistically significant effect on physician readiness. This may indicate that additional education and training in medical skills and protocols may be more effective ways to prepare health personnel to work in complex epidemiological settings. Leibner et al. [16] agrees with this fact, where it was noted that the staff was not prepared for such a load and in most cases lacked the necessary skills in emergency care, as a result, a special algorithm was developed to train medical staff to work with patients with this pathology, which showed extremely high efficiency in improving the quality of staff work with this group of patients.

The found relationship between good organisational management and sufficient clinic funding points to a crucial area in which policy intervention is needed. The idea that healthcare institutions should be prepared to handle spikes in demand is applicable everywhere, even though the precise resource requirements may differ from nation to nation. These results could be used by policymakers to support further funding for primary healthcare facilities, especially for telemedicine capabilities, which were vital during the pandemic. Moreover, creating nationwide inventories of necessary medical supplies and equipment under a rotating inventory system may improve readiness for unforeseen medical emergencies.

The competence of medical staff also plays a vital role, especially in their interactions with doctors and in the application of clinical protocols. Regular training of nursing staff on COVID-19 is of high value and should be continued. Liu et al. [17] investigated the staff performance in China during COVID-19. It was found that doctors and nurses were unprepared to work under pandemic conditions, reflected in low treatment efficacy, high staff morbidity, and early psycho-emotional burnout, confirming the need for additional training for staff to improve pandemic performance [18]. Thus, in this study, during the

survey, the respondents also mention the significance of doctors' and nurses' competence in working in this setting. Robust training programmes emphasising crisis management, adaptability, and clinical abilities would be beneficial to healthcare systems worldwide. The current study's findings indicate that regular, focused training sessions greatly increase healthcare staff members' preparedness for handling emergencies. Policymakers should think about requiring yearly crisis preparedness training for all medical personnel, which would include role-playing of a variety of public health events, not simply infectious disease outbreaks. However, Labrague and de Los Santos [19] note the negative impact of training among nurses. The study found that nurses who had undergone specialised training were more stressed by the fear of contracting a new coronavirus infection, which was reflected in lower quality of care.

Another factor of significance noted by participants in this study is the rational triage of patients. Replication of coronavirus patients plays a critical role in pandemic management as it allows rapid and effective assessment of patient severity, prioritisation of treatment for those in need of immediate medical attention, and optimisation of the use of limited healthcare resources. This approach helps reduce the risk of overburdening health facilities and provides more targeted treatment, helping to reduce the spread of the virus and COVID-19 mortality. Gilbert and Ghuysen [20] also cite data that during the pandemic period, the triage protocol changed several times due to the emergence of new diagnostic methods other than polymerase chain reaction, as well as to the acquisition of experience in the treatment of this group of patients, which reflects the high importance of triage for foreign clinics. Thus, Alhaidari et al. [21] noted that a rational triage system speeds up care, reduces emergency department costs, and offloads staff, especially during a pandemic.

This study primarily examines how the COVID-19 pandemic affected PHC performance in Kazakhstan, but it's also important to take into account the possibility that several pre-existing problems within the healthcare system and external socio-economic factors may have also had an impact on the observed outcomes. The healthcare system in Kazakhstan, like many other post-Soviet nations, has undergone reforms since independence. Pre-existing problems could have made the pandemic more difficult to contain, including inadequate funding, unequal distribution of healthcare resources between urban and rural areas, and ageing infrastructure [22]. These systemic issues could have affected PHC facilities' capacity to respond to the crisis.

Socioeconomic variables also have a significant impact on healthcare outcomes. The economic conditions in Kazakhstan, such as income inequality and regional disparities, may have affected population health overall and access to healthcare services. These variables may have also had an impact on the workload and effectiveness of PHC facilities during the pandemic, as well as their ability to handle the increased demand. Finally, cultural factors and public health literacy levels may have had an impact on how the population responded to preventive measures and sought medical attention during the pandemic.

However, this study was conducted only in Kazakhstan, and its results may be limited by the national specificity of the healthcare system. A comparative analysis of the situation in different countries should be carried out to get a broader picture and identify common patterns. Further research focusing on the impact of differences in emergency care in Kazakhstan on the quality of performance in the setting of a new coronavirus infection is needed to complement the findings of this paper. The results obtained can be used to develop recommendations to improve the training and activities of medical organisations in the spread of COVID-19 and other infectious diseases. Special attention should be paid to the issues of personnel policy, logistical, and medicinal supply, as well as information support of anti-epidemic measures. It is also recommended that research in this area should continue to continuously improve the healthcare system.

CONCLUSIONS

The study identified a range of key factors determining the performance of medical staff in Kazakhstan during the COVID-19 pandemic. Firstly, nurses' competence was found to be more dependent on effective interaction with doctors and prompt training, while regular QI and use of SOPs did not show statistically significant effects on their professional competence.

The trend of increasing numbers of young nurses with tertiary education deserves special attention. This indicates an improvement in educational standards

and may improve the quality of health services in the future, but at the moment it poses some difficulties in implementing innovations as staff lack the experience to effectively utilise new treatment protocols and work on the ward. Prompt training, provision of medicines, separation of patient flow and preventive community outreach were also important to the effective work of general practitioners during the pandemic. These factors, along with sufficient diagnostic and treatment equipment, were key to overcoming the epidemic. Furthermore, a strong correlation was found between doctors' and nurses' competence and their willingness to work during a pandemic, emphasising the significance of psychological resilience and training. The effective management of the organisation also depended on the management's ability to adapt to changing conditions, to communicate effectively with the public and to interact with regulatory authorities.

In conclusion, ensuring that clinics have the necessary transport, equipment, and medicines, as well as competent and trained staff, are key factors in ensuring that health facilities can operate effectively in a pandemic. All these findings emphasise the significance of an integrated approach to the management of healthcare facilities, including the quality of education and training of healthcare personnel, effective communication within the team, and providing the necessary resources to adequately respond to health emergencies. It is critical to recognise some of this study's limitations. The use of questionnaires that rely solely on self-reported data raises the possibility of biases such as social desirability bias or recollection bias, which could skew the results. Furthermore, the study's cross-sectional design gives us only a momentary view of the circumstances, making it difficult for us to monitor developments throughout the epidemic. Despite having a high sample size, the questionnaire approach might not fully capture the complexity of the experiences of healthcare workers and might overlook subtle insights that could be discovered using qualitative methods. Additionally, while the study's emphasis on the perspectives of healthcare workers is essential, it excludes the opinions of patients and managers of the health system, which could offer a more thorough assessment of PHC performance during the pandemic. Finally, the analysis may not have properly taken into consideration regional differences in COVID-19 impact and healthcare resources within

Kazakhstan, which could restrict the applicability of the findings to all regions of the nation.

Further research could develop in several directions. Firstly, benchmarking with other countries can provide a unique opportunity to learn what strategies and approaches have been effective in diverse economic and cultural contexts. This will help in adapting successful practices and lessons learnt for Kazakh PHCs. A second area of focus could be to investigate the long-term effects of the pandemic on PHC. Such analyses will help to understand what changes in care for this patient group have been most sustainable, and what strategies are used after a crisis. A third major area is to assess the impact of government support on PHC during a pandemic. Understanding the effectiveness of different support programmes and their contribution to the survival and development of PHC will provide valuable guidance for future public policy interventions.

Article information and declarations

Data availability statement

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

Ethics statement

All procedures performed in studies involving human participants were by the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. A study was approved by the National Ethics Commission of the Salidat Kairbekova National Research Centre for Health Development on September 21, 2022, No 1045-B.

Author contributions

Study design: AM, DO, AT; data collection: AT, TS, IF; data analysis: TS, DO; supervision: AM, AT; manuscript writing: AM, DO, TS; critical revision for important intellectual content: AM, AT, IF.

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Conflict of interest

The authors declare no conflict of interest.

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VIA MEDICA

ORIGINAL ARTICLE

THE EFFECT OF EXECUTIVE MANAGERS' WALK ROUND ON PATIENT SAFETY CULTURE IN EMERGENCY NURSES

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ABSTRACT

INTRODUCTION: Effective teamwork is vital in providing safe and effective patient care, especially in a high-risk setting such as the emergency ward. The culture of patient safety has a direct impact on the way work is performed and, consequently, on the safety of patients. One of the ways to promote the patient safety culture is to support the hospital's management team and improve the teamwork climate. This study was conducted to investigate the effect of executive managers' walk-round on patient safety culture in emergency ward nurses.

MATERIAL AND METHODS: This quasi-experimental study was carried out in four emergency wards (two wards for the experimental group and two wards for the control group) in Darab Hospital. From each group, 32 nurses were selected by stratified random sampling method and participated in the study. For the experimental group, executive managers' walk rounds were conducted for five months. The safety culture questionnaire was completed before and after the intervention in both groups. Data were analysed with SPSS22.

RESULTS: The average scores of the patient safety culture of the two experimental and control groups were not statistically different before the intervention. Overall, the total score of the intervention group was 130.44 ± 7.80 and that of the control group was 124.19 ± 8.76 after the intervention, which showed a statistically significant difference (p ≤ 0.001). More specifically, in the intervention group, the scores of "teamwork within hospital units" (p = 0.015), "overall perceptions of safety" (p = 0.042), "communication openness" (p = 0.020), "non-punitive response to the error" (p = 0.001), "feedback and communication about errors" (p = 0.021) were higher compared to the control group.

CONCLUSIONS: This study provided further insight into the importance of hospital management's support in improving patient safety culture. Executive managers' walk-rounds increased the culture of patient safety perceptions of emergency ward nurses; thus, it is suggested to regularly conduct executive managers' walk-rounds to improve the level of patient safety and increase the quality of service to patients.

KEYWORDS: patient safety; executive managers' walk-round; patient safety culture; nurse; emergency ward

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INTRODUCTION

Safety culture forms the cornerstones of excellent care delivery that should be considered in all pa-tient care programs [1]. Patient safety is defined as "the act of avoiding, preventing, or ameliorating adverse outcomes or harms resulting from the hospital

care process" [2]. The infrastructure of healthcare is based on the culture of patient safety [1, 2] *i.e.*, the foundation and organization of the healthcare system are built around prioritizing and maintaining patient safety. This implies that all healthcare practices, policies, and systems are designed with the primary goal of ensuring that patients are protected from harm and receive safe, high-quality care. Organizational culture encompasses the shared values, beliefs, and norms that influence behaviour within an organization, and in healthcare, it is crucial for fostering a patient safety culture. This means that patient safety is deeply embedded in every aspect of the organization, starting with leadership commitment to safety, which is reflected in policies, actions, and resource allocation [3]. It permeates through open communication, where staff at all levels are encouraged to report safety concerns without fear of retribution. Continuous learning and teamwork are emphasized, ensuring that safety practices are consistently applied and improved upon. By integrating patient safety into the core of organizational culture, healthcare providers create an environment where safety is a fundamental and intrinsic value, leading to better patient outcomes and a more resilient healthcare system [4, 5]. Positive attitudes towards safety reduce unsafe behaviours among healthcare professionals [6]. Vikan's study showed that enhancing patient safety culture decreases adverse events (AEs) [7]. Unsafe services harm patients and families, add psychological stress to healthcare staff, and lead to accidents due to the influence of culture on behaviour. Healthcare-related AEs are the third leading cause of mortality in the United States [6]. Moreover, studies have shown that on average, in approximately 10% of all hospitalized cases, patients sustain harm to various degrees, while it is estimated that up to 75% of these errors can be prevented [8]. It is estimated that between 5% and 10% of health-related costs are caused by unsafe clinical services that lead to harm to patients [9].

Untoward medical accidents which can be defined as adverse events or incidents that occur during medical care, are also very common in Iran. In a study conducted in Jahorm in Fars province, it was revealed that 91% of patients had an untoward accident [10]. Nursing errors, as a part of these accidents, can occur at any point in nursing activities and procedures, and the consequences may be weak or severe [11]. Nursing is a stressful task and a stressful profession with a high workload, long working hours, emotional strain, exposure to violence and abuse, and risk of occupational hazards, with a high rate of occupational accidents and diseases [12]. The emergency ward significantly impacts other hospital wards [13], in which urgent services are provided to patients at all hours around the clock, showing the importance of optimal performance and effective communication between nurses as well as communication with other healthcare professionals of nurses to maintain the safety of patients and the quality of patient care [14].

In 2020, World Health Organization (WHO) also emphasized the need to link patient safety and professional work settings and introduced the campaign "Safe Health Workers, Safe Patients" on Global Patient Safety Day. In 2022, Kizir et al. [15] concluded that safe nursing environments positively affect patient safety attitudes. Emergency nurses face health and safety risks that impact their well-being and patient care quality. Unsafe conditions harm patient safety, while organizational culture and safety perceptions influence performance and outcomes [16]. Clarifying staff values and beliefs about safety is key to reducing accidents and improving performance [17]. Lee et al. [2] emphasized that hospital management and supervisors play a crucial role in motivating nurses to adopt patient safety behaviours, ensuring psychological safety for staff.

Effective safety culture management is essential for organizational safety improvements [18]. Managers' walk-rounds provide a structured approach for hospital managers to discuss safety with frontline staff, enhancing patient safety culture [19, 20]. These walk-rounds enable nursing leaders to engage directly with healthcare staff, demonstrating a commitment to improving patient care quality [21]. Executive managers' walk-rounds promote a safety culture and improve patient safety and care quality [22]. To review the organizational strategy to achieve the goals aligned with the study, including increasing patient safety and improving patient care, as well as increasing the resources involved in this progress, including improving the treatment staff, managers' walk-round holds a predictable meeting for discussion between managers and front-line personnel by identifying opportunities to improve care processes that lead to better patient safety outcomes [21]. Healthcare and safety managers can reinforce and cultivate a strong belief in the importance of safety and a positive safety culture among all service providers. By doing so, they play an effective

role in improving their work environment and ensuring patient safety [23]. US studies found that management rounds improved safety, care quality, and safety awareness in paediatric emergency and pharmacy wards [24, 25]. Given the important role of executive managers in ensuring patient safety, the authors developed and studied the effects of the innovative executive walk-round program on patient safety culture, which is explained below.

Hospital intervention program and study purpose

The designed program is unique in that it included different categories of nurses, such as ward nurses, ward supervisors in shifts, head nurses, clinical and educational supervisors, and hospital matrons. Additionally, the senior managers of the hospital, including the internal manager of the hospital, the person in charge of quality and safety improvement, and the hospital dean, were also directly involved in the implementation of the walk-round. Furthermore, at the end of the walk-round of senior managers, micro-teaching, defined as the short learning sessions usually lasting between 5 to 20 minutes followed by feedback and discussion to improve specific teaching strategies and techniques, with patient safety content was presented to nurses. Considering the high prevalence of untoward errors and the low safety of patients due to the high rate of medical errors, as well as the importance of increasing patient safety culture on reducing unwanted errors, the present study was conducted to explore the impact of executive managers' walk rounds on emergency ward nurses' perceptions of patient safety culture.

MATERIAL AND METHODS
Design

This quasi-experimental study was conducted in a large general hospital affiliated with Shiraz University of Medical Sciences. The hospital included a triage ward and two lines, each with two emergency wards. One line, comprising two wards, was designated as the intervention site (experimental group), while the other line, also with two wards, served as the control group. All emergency wards were selected randomly and followed similar patient safety policies and approximately the same number of nurses for each ward. The number of referral patients was about 4646 ± 54 and inpatients were about 797 ± 37 for each month in each group. The

workload was different for doctors and nurses, however, this study focused on nurses and the workload for each nurse for each month was 422 patients in each group.

Setting and sample

Based on Pakzad et al.'s [26] study, the sample volume was estimated to be 29 people, taking into account the two-way confidence interval of 5%, and test power of 80%. Considering a 10% subject attrition rate, 32 nurses were considered as the research sample. Stratified random sampling was used for subject selection; the number of selected nurses from each ward was proportional to the total number of nurses so that 32 nurses in the experimental group and 32 nurses in the control group entered the study.

$$n = \frac{(Z_{\frac{\alpha}{2}} + Z_{\beta})^2 \, 2s^2}{(\overline{\chi}_1 - \overline{\chi}_2)^2}$$

The inclusion criteria were willingness to participate in the study and having at least one year of clinical work experience in the emergency ward of the hospital.

Variables and measurements

The primary variable was the impact of the executive walk-round program on patient safety culture. This was measured using the Hospital Survey on Patient Safety Culture (HSOPSC), completed by all participating nurses.

Interventions in the emergency ward

Weekly information posters related to safety tips were installed in the emergency ward. For the experimental group, safety protocols were sent through the channel in the social messenger, including reports on the occurrence of medication errors and other errors, safety tips, and how to interact with colleagues from other treatment groups (laboratory, pharmacy, radiology, *etc.*) Moreover, periodically, safety-related messages were placed in the form of pamphlets, posters, or stands in the wards. Safety manuals were also provided to nurses. These items were prepared based on Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS). In addition to the mentioned issues, notebooks were placed to record suggestions related to improving safety in emergency wards. Besides, nurses could send their opinions, criticisms and suggestions to the hospital matron through WhatsApp

Table 1. Overview of walk-round topics, time and type of executive managers

Executive managers	Time	Walk round topic
Senior managers	Week 1, morning	Emergency department safety, patient safety
Medial managers 1	Week 1, morning	Emergency department safety
Medial managers 2	Week 1, evening	Emergency department safety
Medial managers 1	Week 2, morning	High-risk drugs, documentation
Medial managers 2	Week 2, evening	High-risk drugs, documentation
Senior managers	Week 3, morning	Risk of falling, high-risk patients
Medial managers 1	Week 3, morning	High-risk patients: unconscious, elderly and infants
Medial managers 2	Week 3, evening	High-risk patients: unconscious, elderly and infants
Medial managers 1	Week 4, morning	Personal protection
Medial managers 2	Week 4, evening	Personal protection
Senior managers	Week 5, morning	Leadership, and supervision
Medial managers 1	Week 5, morning	Improvement of methods
Medial managers 2	Week 5, evening	Improvement of methods
Medial managers 1	Week 6, morning	Communication skills, mutual support
Medial managers 2	Week 6, evening	Communication skills, mutual support
Senior managers	The morning of the first week of the month up to three months	Review of suggestions and reported errors, an overview of department safety, patient safety, mutual support
Medial managers 1, 2	The morning of the second and fourth week of the month up to three months	Review of suggestions and reported errors, an overview of department safety, patient safety, mutual support

social network. This program was accessible from inside and outside the hospital and anonymity/no-nanonymity was optional. Another online program (hospital's electronic incident reporting system) was also available for people to report errors anonymously which is utilized to report, track, and analyse patient safety incidents. This system allows healthcare staff to promptly document safety issues or adverse events, thereby facilitating timely interventions and promoting continuous improvement in patient care. In both cases, after registering the events, the nurses received a tracking code through which they could track the cases.

Executive managers' walk-round

Walk-rounds were conducted by senior managers (hospital manager, matron, educational and clinical supervisors and infection control, quality and safety improvement officer and hospital dean) during the first, third and fifth week on Saturday. The walk-rounds of medial managers (clinical supervisors, educational supervisors and emergency ward staff) were conducted on Monday mornings and evenings during the first to fourth weeks. The approximate duration of each walk round varied between 30 and 45 minutes. Nurses who failed to participate in the

managers' walk-round (due to busy shifts or no shift on the days when the walk-round was conducted) were asked to participate in one of these repeated walk-rounds. By the way, overtime hours were considered by the hospital manager for the nurses who participated in the meetings outside the shift. The sessions were held in such a way that about 30 to 45 min of the first walk-round of executive managers was held for the experimental group and immediately about 20 min of micro-teaching class was held for both experiment and control groups (Tab. 1). The protocol for the "Executive managers' walk rounds" uses a structured method to engage participating nurses. Executive managers generally start the conversation with guiding questions about safety issues. These questions aim to foster open dialogue and identify any concerns or suggestions nurses may have about patient safety and overall care quality.

At the beginning of each management round, pre-reported suggestions and criticisms of nurses were read, and the managers expressed the actions taken to implement the suggestions in the following meetings. Additionally, the nurses also verbally announced their suggestions to the executive managers and received feedback in the walk-round meeting of

managers. After the weekly walk-round finished, the walk-round was done by the senior managers in the first week of every month. The medial managers' walk-round was done in the second and fourth week of every month, and this program was carried out for three more months. Subsequently, demographic and patient safety culture questionnaires were completed again by the nurses of both experimental and control groups. After completing the questionnaires, to comply with the ethical issues, the round with the senior and medial managers continued for another two months and all the nurses who worked the shift could participate in the rounds.

Hospital survey on patient safety culture

This questionnaire includes 42 items that measure 12 different dimensions of patient safety culture. These dimensions include frequency of event reporting, overall perception of safety, supervisor/manager expectations and actions promoting safety, organizational learning-continuous improvement, teamwork within hospital units, communication openness, feedback and communication about error, non-punitive response about errors, staffing, management support for patient safety, teamwork across hospital units, and handoffs and transitions. This questionnaire was developed by the Agency for Healthcare Research and Quality (AHRQ) in 2004 [27] and has been used many times to evaluate the opinions of hospital staff about patient safety culture in different parts of the world [28–31]. The validity and reliability of this questionnaire were confirmed in the study by Chen et al. in 2010 [32]. The psychometric evaluation of this questionnaire was done in Iran by Lazemi et al. [33] and it has been used in various studies. In the study by Kakemam et al. [34], the reliability of this questionnaire was reported between 0.69 and 0.90 through the calculation of Cronbach's α. The intervention facilitated an improved reporting of potential errors by providing structured protocols and training sessions aimed at enhancing error recognition and reporting among the staff. This approach led to observed improvements in the accuracy and frequency of error reporting within the study period.

Data collection

Nurses meeting the inclusion criteria were invited via phone calls to participate in the study. The orientation session was meticulously organized to ensure participants were well-informed about the study

and adequately prepared for their involvement. During the session, the study's purpose was thoroughly explained through a detailed presentation, highlighting the goals, objectives, and significance of the research. Written informed consent was then obtained, with facilitators distributing consent forms, explaining the consent process, and addressing any questions participants had to ensure they fully understood their rights. Participants were also asked to complete the HSOPSC during the session, with clear instructions provided and time allocated for its completion. Additionally, separate WhatsApp channels were created for the control and experimental groups to facilitate communication, disseminating important information such as dates for the managers' walk-rounds and other announcements. This comprehensive orientation session ensured that all participants were properly briefed, consented, and equipped with the necessary information to participate in the study. Separate WhatsApp channels were created for the control and experimental groups to disseminate information, including dates for the managers' walk-rounds and other announcements.

A preliminary workshop was scheduled for both groups to cover topics such as patient safety culture, safety-threatening situations, and TeamSTEPPS, developed by the AHRQ [35]. This included communication skills, mutual support, leadership, and situation monitoring. Each skill was first presented as a lecture. Then, clinical cases were presented and discussed.

Data analysis

IBM SPSS22 was used for data analysis. The Kolmogorov–Smirnov case was used to check the normal distribution of data. Frequency and percentage as well as mean and standard deviation were used to report descriptive statistics. A paired t-test was used to determine the difference in nurses' safety culture before and after the managers' walk-round in each group. To compare the safety culture of nurses in two groups, an independent t-test was used. Figure 1 provides a comprehensive summary of the entire research methodology process.

Ethical considerations

The present study was conducted in accordance with the principles of the Revised Declaration of Helsinki, Statement of Ethical Principles Regarding Physicians and Other Participants in Medical Research Involving Human Subjects. After obtaining the code
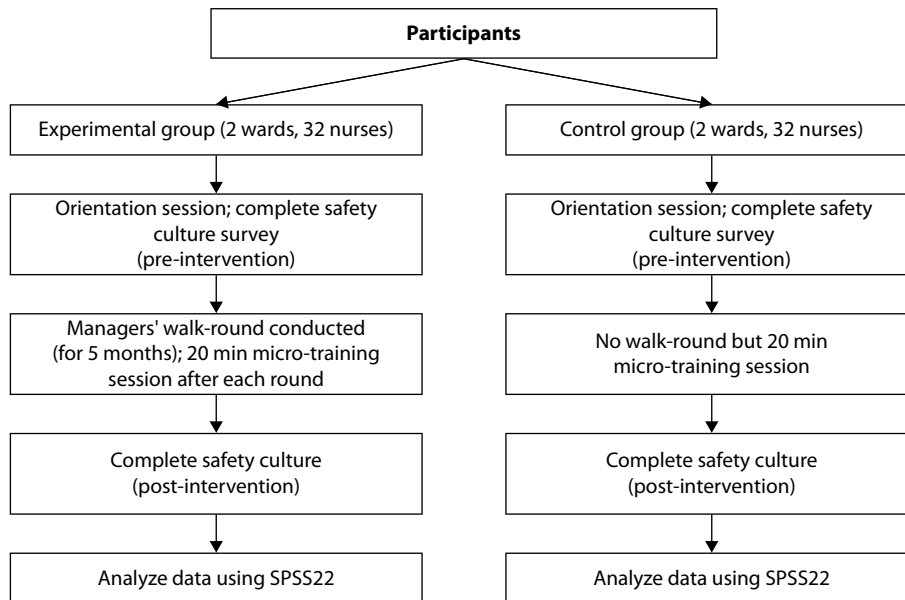
FIGURE 1. Overview of research methodology: evaluating the impact of hospital managerial walk rounds on patient safety

of ethics in the research with code of ethics No.: IR.SSU.REC.1400.174, the researchers presented to the hospital officials and explained the objectives of the study to them.

All participants including senior and medial managers of the hospital signed a written informed consent to participate in the study. All participants were assured all personal information would remain confidential and that they could withdraw from the study at any stage. Moreover; the research ethics committees of Shahid Sadoughi University of Medical Sciences, Yazd, Iran approved the study (Ethical code: IR.SSU.REC.1400.174).

RESULTS

In total, 64 nurses participated in this study, 32 in the intervention, and 32 in the control group. Besides, 23 nurses (71.9%) in the experimental group and 20 nurses (62.5%) in the control group were female. Also, 30 nurses (93.75%) in the experimental group and 29 nurses (90.63%) in the control group hold a bachelor's degree, and the rest hold a master's degree, respectively. Besides, 22 nurses (68.87%) in the experimental group and 22 nurses (68.87%) in the control group had a rotating shift, and the rest had a fixed morning shift. In terms of qualitative and occupational demographic variables such as gender, education, and work shift, there was no statistically significant difference between the two study groups (Tab. 2).

There was no difference between the experimental and control groups in the mean scores of different dimensions of patient safety culture before the intervention. According to the results of the independent t-test, it was found that there was a difference between the two study groups after the test in the dimensions of overall perceptions of safety ($p = 0.042$), teamwork within hospital units ($p = 0.015$), communication openness ($p = 0.020$), non-punitive response to the error ($p = 0.001$), and feedback and communication about errors ($p = 0.021$). In other words, the intervention significantly enhanced these dimensions in the experimental group compared to the control group, while no significant differences were found between the groups in other dimensions (Tab. 3).

The mean overall score of patient safety culture in the experimental group increased significantly from 123.89 ± 13.60 before the intervention to 130.44 ± 7.80 after the intervention ($p = 0.001$). whereas no statistical difference was observed in the control group ($p = 0.503$). The mean overall score of the patient safety culture of the experimental and control groups before intervention did not show any statistically significant difference ($p = 0.503$); yet, after intervention, the mean overall score of the patient safety culture in the experimental group was higher than that of the control group, which was statistically significant ($p = 0.001$) (Tab. 4).

Table 2. Demographic characteristics of the participating nurses				
Group		Control	Experimental	p value
Demographic characteristics		Mean (cSD)	Mean (± SD)	
Age		33.11 (± 4.96)	34.85 (± 5.46)	0.226
Experience working in the emergency		7.67 (± 3.21)	9.22 (± 4.41)	0.145
Total Experience working		9.59 (± 4.76)	11.58 (± 5.59)	0.116
		Frequency [%]		
Gender	Female	20 (62.5)	23 (71.88)	0.471
	Male	12 (37.5)	9 (28.12)	
Education	Bachelor's degree	29 (90.63)	30 (93.75)	0.902
	Master's degree	3 (9.37)	2 (6.25)	
Working shift	Only morning	12 (68.75)	10 (31.25)	0.84
	Rotational	20 (31.25)	22 (68.75)	

cSD — common standard deviation; SD — standard deviation

DISCUSSION

This study was carried out to investigate the effect of executive managers' walk-round on patient safety culture in emergency nurses. Based on the findings of patient safety, the overall score of patient safety culture after the intervention was significantly higher in the intervention group compared to the control group, which was statistically significant. The results of this study demonstrated that there was a significant difference between the two experimental and control groups after intervention in the dimensions of the overall perception of safety, teamwork within hospital units, communication openness, non-punitive response to the error, and feedback and communication about errors in the experimental and control groups, but there was no statistically significant difference in other dimensions. Faridi et al. [36] found that electronic training improved the safety culture in nurses, consistent with the present results. Najafi Ghezeljeh et al. [37] concluded that e-learning increased nurses' knowledge, skills, attitudes, and competence towards patient safety culture. The results of the systematic review conducted by Alsabri et al. [38] revealed that teamwork and educational interventions based on personnel communication promote safety culture in emergency wards and the implementation of safety culture programs may be considered to reduce the incidence of medical errors and complications. Sadrollahi et al. [39] found that eight 6–8-hour workshop-style training courses on caregiving ethics effectively promoted patient safety culture among clinical nursing managers. Agbar et al. [40] conducted a systematic review and meta-different levels of analysis to examine empirical evidence on the impact of implementing patient safety education programs on patient safety culture and concluded that patient safety education can promote patient safety culture in healthcare professionals. In explaining the findings of the present study, it can be said that the walk rounds support the hospitals' senior and medial managers of the organization, and the point that one of the topics related to safety was discussed every week in the meetings held, showed the importance of the program, and the repetition of this program in consecutive weeks led to its effect on the nurses' perception of patient safety culture. On the other hand, nurses could freely convey their opinions and suggestions to the senior and junior management, and later, seeing the possible changes made and applying the suggestions, they became more encouraged. During the sessions, it was tried to discuss disagreements between employees as well as those between employees and managers with intra-group discussions, and clarifications were made on the discussed issues regarding safety. Some of the structural problems were related to the existence of disagreements or the lack of a safety protocol implementation manual. During these meetings were identified controversial bottlenecks and specified implementation methods. The discussion sessions helped to improve cooperation and interactions among the personnel. Lee believes that the support of hospital management and supervisors motivates nurses to develop patient safety behaviours. Of course, these supports should be accompanied by an increase in mental safety for nursing staff which affects patient safety through some behaviours in nursing staff including

Table 3. Comparison of patient safety culture before and after the intervention within and between groups

Dimensions	Group	Pre-test; mean (± SD)	Post-test; mean (± SD)	p value (within group)
Frequency of events reported	Experimental	10.93 ± 1.82	11.37 ± 1.18	0.282
	Control	10.63 ± 2.11	11.04 ± 1.68	0.194
	p value	0.583	0.402	
The overall perception of patient safety	Experimental	8.15 ± 1.69	9.39 ± 1.74	0.001
	Control	8.30 ± 1.46	8.59 ± 1.63	0.026
	p value	0.890	0.042	
Expectations and actions promoting patient safety	Experimental	12.59 ± 2.60	14.52 ± 2.10	0.001
	Control	12.85 ± 2.68	13.89 ± 1.74	0.08
	p value	0.720	0.236	
Organizational learning	Experimental	8.93 ± 1.95	10.37 ± 1.90	0.001
	Control	9.78 ± 2.41	10.48 ± 2.12	0.060
	p value	0.055	0.840	
Teamwork within units	Experimental	13.59 ± 3.51	15.55 ± 1.87	0.001
	Control	13.30 ± 3.12	14.00 ± 2.60	0.127
	p value	0.745	0.015	
Communication openness	Experimental	8.44 ± 1.60	9.70 ± 1.96	0.002
	Control	7.93 ± 1.44	8.44 ± 1.91	0.219
	p value	0.216	0.020	
Feedback and communication on errors	Experimental	9.74 ± 2.05	10.63 ± 1.73	0.034
	Control	9.70 ± 2.25	10.11 ± 1.85	0.296
	p value	0.950	0.293	
Non-punitive response to errors	Experimental	9.89 ± 2.39	11.44 ± 2.58	0.003
	Control	8.59 ± 2.82	8.96 ± 2.23	0.536
	p value	0.074	0.001	
Staffing	Experimental	9.22 ± 3.59	8.04 ± 2.98	0.045
	Control	8.52 ± 2.85	7.33 ± 2.45	0.002
	p value	0.428	0.348	
Management support for patient safety	Experimental	8.18 ± 1.52	9.22 ± 1.25	0.002
	Control	8.33 ± 1.57	8.59 ± 1.42	0.355
	p value	0.726	0.090	
Teamwork across hospital units	Experimental	12.78 ± 1.42	12.96 ± 1.28	0.631
	Control	12.44 ± 1.09	12.63 ± 1.52	0.434
	p value	0.338	0.389	
Handoffs and transitions	Experimental	12.18 ± 1.69	12.52 ± 1.99	0.462
	Control	11.26 ± 2.85	11.22 ± 1.99	0.921
	p value	0.152	0.021	

SD — standard deviation

Table 4. Comparison of total scores of the patient safety culture before and after the intervention within and between groups

Variable		Pre-test; mean (± SD)	Post-test; mean (± SD)	p value (within group)
Patient safety culture	Experimental	123.89 ± 13.60	130.44 ± 7.80	0.001
	Control	121.83 ± 124.19	124.19 ± 8.76	0.35
	p value	0.503	0.001	

SD — standard deviation

error reporting and transparency, engagement and performance, team collaboration, stress reduction, and innovation and improvement [2]. In the present study, managers repeatedly emphasized the importance of patient safety during walk-rounds and micro-teaching; they mentioned that "patient safety is one of the hospital's priorities" and the presence of managers alongside the staff and repetition of the walk-round probably might have improved the attitude of nurses toward patient safety. The presence of managers and the discussion of safety-related problems may have strengthened the relationship between managers and nurses. In addition, solving the challenges between the emergency ward and other wards, it was tried to help improve the communication between the emergency ward and other wards, which may have helped to improve the nurses' safety attitude. Moreover, managers' involvement also provided an opportunity for staff to participate in patient safety initiatives. Promoting a supportive and non-punitive work environment has probably encouraged personnel to provide services in accordance with safety standards, which is considered important for both patients and health service providers in ensuring patient safety and service effectiveness. Mostafaei et al. [41] stated that hospital managers should consider improving patient safety as the main priority and personnel should be encouraged to report errors without fear of punishment and blame. During the walk rounds, one of the key focus areas was implementing interventions aimed at explaining the types of errors and increasing awareness of safety issues. These interventions were presented by managers and supervisors to ensure staff understood the nature of errors and the importance of reporting them. On the other hand, error reporting boxes were placed in different places in the emergency ward to report possible errors. These notebooks were anonymous, and the identities of the people were kept secret. Also, the personnel could register errors through a software program with anonymous access that was on the computers in the ward. In this case, a tracking code was given to the individual, who could track the actions taken by entering the tracking code. During the walk rounds, the authors tried to establish a friendly atmosphere between the managers and nurses of the emergency ward, *etc.*, so that later, the concerns related to the punitive response to the error report were resolved and the paths of error reporting were paved.

Limitations of the study

This study was conducted in the emergency wards of one hospital and the results were specific to the research community; thus the generalization of findings to other settings should be done with caution. The results indicated the positive effect of managers' walk-round on some dimensions of patient safety culture in nurses. Hence, it is essential to promote safety culture among nurses by first conducting a thorough needs assessment to identify the specific dimensions of safety culture that are underdeveloped. Based on this assessment, targeted strategies should be implemented to address these areas. This might include focused training programs, improved communication protocols, enhanced reporting systems, and leadership support initiatives to ensure a comprehensive and effective approach to fostering a strong safety culture.

In considering the limitations of this study, it is essential to reflect on the potential applicability of the findings to other organizations. While conducted in a specific environment, the study suggests the potential transferability of results to similar settings. However, variations in organizational culture, resources, and operational contexts across institutions may influence the generalizability of these findings. Therefore, caution is advised when extrapolating these results beyond the study setting. Further research in diverse organizational contexts is recommended to validate the broader applicability of these findings.

CONCLUSIONS

In conclusion, the study highlights the significant positive impact of executive managers' walk-rounds on patient safety culture among emergency nurses. The intervention group showed substantial improvements in various dimensions of safety culture compared to the control group, reflecting enhanced perceptions of safety, teamwork, communication openness, and responses to errors. These findings underscore the importance of managerial engagement and structured discussions in fostering a supportive environment where nurses feel empowered to contribute to safety initiatives and report errors without fear of reprisal. Continued emphasis on these strategies can further enhance patient safety outcomes and promote a culture of continuous improvement in healthcare settings.

Article information and declarations

Data availability statement

The dataset of this study can be provided if needed.

Ethics statement

The medical ethics committee of Shahid Sadoughi University of Medical Sciences approved this study (Ethical code: IR.SSU.REC.1400.174). Informed written consent was obtained from all nurses and managers, and confidentiality of information was assured. All study questionnaires were collected anonymously.

Author contributions

All authors contributed to the design and conduct of the study. Designed the study and wrote the manuscript — BA; involved in the interpretation of the data, and the coordinator researcher — MJ. PN and NS collected the data and conducted the intervention — PN and NS. All authors revised the manuscript critically and final approval of the manuscript.

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Conflict of interest

The authors declared no conflicts of interest with respect to authorship and publication of this article.

Supplementary material

None.

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ORIGINAL ARTICLE

EVALUATION OF HOSPITAL PREPAREDNESS FOR DISASTERS: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

INTRODUCTION: This bibliometric analysis focuses on hospital preparedness for disasters research perspective & evaluation method especially in range of COVID pandemic era. The research presents a comprehensive analysis of research articles spanning 2019 to 2023, a total of articles from Scopus database 2,571, after filtered with inclusion criteria there are 145 articles selected.

MATERIAL AND METHODS: The methodology employed in this article is bibliometric analysis utilizing Scopus Analytics & VOSviewer, trends in publication output, geographical distribution, prominent authors, and subject areas were explored.

RESULTS: The dataset highlighted fluctuations in yearly publications between 18 and 40 articles per year, with peaks in 2021 with 40 articles in total. The United States led in contributions with 45 articles, followed by diverse global engagement from countries like Iran (20), Australia (9), and South Korea (9). The keyword "nursing" dominates the research field with 101 documents followed by "medicine" with 74 documents related to hospital disaster preparedness strategies and focusing on exploring human factors and community readiness for patient care during post-disaster conditions. VOSviewer analysis unveiled thematic clusters emphasizing COVID-19, hospital emergency service, healthcare personnel, and disaster nursing, elucidating interconnectedness within healthcare research. Notably, keywords like "disaster planning", "disaster preparedness", and "disaster management" emerged as pivotal in assessing hospital readiness during disasters.

CONCLUSIONS: This study underscores the necessity of evaluating hospital preparedness for disasters, emphasizing multidisciplinary approaches and key thematic clusters, providing foundational insights for enhancing disaster management strategies in healthcare settings.

KEYWORDS: bibliometrics; COVID-19; disasters; health facilities; hospitals

Disaster Emerg Med J 2024; 9(4): 237–249

INTRODUCTION

Government Regulation Number 21 of 2008 on Disaster Management defines a disaster as a series of events that threaten society and can be caused by natural, non-natural, and human factors without warning [1]. These disasters result in various impacts including loss of life, environmental damage, property loss, and psychological issues. Over 2.6 billion individuals worldwide have been affected by natural disasters in the last decade, with serious impacts

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such as injuries and damages [2, 3]. Indonesia, with approximately 87% of its territory vulnerable to natural disasters, frequently experiences various types of disasters like floods, cyclones, and landslides [4, 5]. The year 2020 recorded 2,939 disaster events, causing over 6.4 million people to be displaced, 370 fatalities, and significant damage to thousands of facilities [4].

Hospitals play a crucial role in addressing various types of disasters, particularly in providing healthcare services to affected populations. They are expected to operate during and after disasters. When hospitals fail to function in disasters and emergencies, whether due to structural or functional issues, they cannot promptly cater to victims' needs during the most critical periods [6, 7]. The early hours of crises triggered by natural disasters are critical for victim safety and minimizing fatal impacts. The limited timeframe necessitates swift and effective emergency actions to locate and rescue the injured while preventing or containing additional hazards. However, both objective and subjective factors often hinder timely and efficient emergency responses. These constraints are frequently associated with powerful and rapid hazardous events like earthquakes, storms, or floods, disrupting the implementation of emergency management plans [8, 9]. Incidents involving mass casualties and disaster scenarios pose significant challenges to medical facilities such as hospitals, necessitating adequate preparedness measures. The evaluation of medical facility readiness can be conducted using multiple dimensions or aspects assessments. A comprehensive analysis involves structural, functional, and organizational factors, encompassing infrastructure facilities, technical facilities, safety standards, workflow organization, connections with external facilities, human resource management, crisis planning, and communication strategies [10–13].

Evaluation of hospital preparedness for disasters is an important component of improving disaster preparedness. There are several approaches and tools available for evaluating hospital disaster preparedness. One approach is a multi-criteria decision-making approach, which involves evaluating the readiness of hospitals and proposing a ranking of them based on measurable elements and standards [14]. Another approach is to use a hospital disaster risk management evaluation model, which can embed standards and measurable elements to measure a hospital's preparedness in disasters [15].

There are also assessment tools available, such as the Hospital Disaster Preparedness Self-Assessment Tool, which can assist hospitals in revising and updating existing disaster plans or in the development of new plans [16]. Additionally, models are being developed for the evaluation of hospital disaster resilience, which include variables such as hospital safety, emergency services, surge capacity, command, disaster plan, logistics, staff ability, and more [16]. These tools and approaches can help hospitals assess their preparedness for disasters and identify areas needing improvements.

This study employs Scopus Advanced Search using the keywords "hospital," "disasters," and "preparedness" yielding 145 articles spanning from 2019 to 2023. Subsequently, these articles will undergo bibliometric analysis using the VOSviewer application to identify relevant keywords. Thereafter, VOSviewer will be utilized for clustering, a method for grouping objects based on similarities or differences [17]. The clustering criteria are based on keywords relevant to this research focus, namely "evaluation of hospital preparedness for disasters".

MATERIAL AND METHODS

The methodology employed in this article is bibliometric analysis. Bibliometric analysis is a term used to refer to a specific research methodology and development aimed at gathering and evaluating relevant studies on a particular topic focus. The objective of bibliometric analysis is to identify, assess, evaluate, and interpret all available studies within the field of interest, with specific research questions [18]. This bibliometric analysis also aims to provide characterization, and an overview of research trends, methods, and coverage fields investigated within the study of digital literature databases over a specific period [19, 20].

In this study, the advanced search feature of the Scopus database was utilized to meticulously curate relevant scholarly articles. The search for articles on the database has been done on 20th March 2024. The search strategy incorporated specific keywords and filters including "hospital", "disaster", and "preparedness" within the title, abstract, and keywords (TITLE-ABS-KEY), ensuring the inclusion of articles pertinent to the research focus. Moreover, articles published between 2018 and 2024 were targeted (PUBYEAR), limiting the scope to recent developments in the field. Restriction to

journal articles (DOC-TYPE "ar") and indexed sources (SRCTYPE "j") upheld the standard of scientific rigor. Further refinement involved selecting articles from subject areas such as Nursing (SUBJAREA "NURS"), Health (SUBJAREA "HEAL"), or multiple disciplines (SUBJAREA "MULT"). Language criteria (LANGUAGE "English") were imposed to ensure linguistic consistency, while only articles in the final stage of publication (PUBSTAGE "final") were considered, reflecting the culmination of rigorous peer review. This comprehensive approach aimed to compile a robust dataset of high-quality scholarly literature essential for research analysis.

TITLE-ABS-KEY (hospital AND disaster AND preparedness) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "NURS") OR LIMIT-TO (SUBJAREA, "HEAL") OR LIMIT-TO (SUBJAREA, "MULT")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (PUBSTAGE, "final"))

For ease of understanding, the process and workings of a bibliometric analysis can be outlined with PRISMA as seen in Figure 1.

The stages of the bibliometric analysis above require the assistance of applications to streamline the process. The applications used are Scopus Advanced Search and VOSviewer. Both applications are commonly used for bibliographic analysis. Scopus advanced search is designed to illustrate citation metrics using metadata obtained from Scopus' internal indexing institution with concrete data. The Scopus advanced search website enables searches based on authors, publication names, titles, and keywords, and can map the year range of articles along with citation counts. Meanwhile, VOSviewer is utilized to visualize bibliographies or datasets containing bibliographic fields such as titles, authors, journal names, and so forth. In the academic realm, VOSviewer is employed for bibliometric analysis, identifying research gaps in specific topics, finding the most widely used references in particular fields, and more [17, 21].

The hospital disaster preparedness analyzed in this article comes from the Scopus database metadata. The author takes article metadata from Scopus with certain keywords along with inclusions and exclusions. The stages in the data collection process which are then analyzed in VOSviewer are carried out in several stages consisting of: First stage. At this stage the author carries out several processes, namely 1) Downloading journal article metadata with the keyword "hospital disaster preparedness" using Scopus advanced search 2) Data is stored in RIS format. 3) RIS data is analyzed using the VOSviewer application to get visuals. 4) The results of the analysis with VOSviewer are written in this article.

In the second stage, the authors conducted several processes: 1) downloading metadata and journal articles using Scopus Advanced Search; 2) storing the acquired data in RIS format; 3) performing narrative analysis within the Mendeley reference program, focusing on the folder labeled hospital disaster preparedness; 4) analyzing the data obtained in RIS format from Scopus Advanced

Identification	Step 1	Records were identified using the search database of Scopus (n = 2,517)
Assessment of eligibility	Step 2	Publication dates from 2019 until 2023 (n = 934)
Inclusion and exclusion	Step 3	Inclusion criteria Eligible records were assessed based on the area of nursing, Health professions, multidisciplinary (n = 189)
	Step 4	Records were identified using document type "article", publication stage "final", journal language "English" (n = 145)
Selection	Final	Records are selected (n = 145)

FIGURE 1. The steps of searching and selecting articles

Search using VOSviewer to generate visual data; and 5) presenting the outcomes of this analysis in this article.

Stage three. In this stage, the authors analyzed the author's network contributing to the study of hospital disaster preparedness between 2019 and 2023. The analysis results were visualized in graphical form, depicting the map and emerging themes categorized within the output of the VOSviewer program. This visualization encompassed aspects such as 1) the varying thickness of connecting lines and circles, reflecting the magnitude of the VOSviewer analysis results; 2) several numerical values were divided into links, representing networks, by calculating link strength (measured through full or fractional counting) and the frequency of occurrence. Moreover, this paper encompassed several types of analyses, including a) citation analysis, visualizing the documents under observation, and connecting those documents that cite the same articles; this analysis reveals citation relationships among documents; b) bibliographic coupling, visualizing, and creating networks of articles based on shared references; this analysis indicates the proximity of studies among documents; c) co-authorship analysis, examining collaborations among authors; this analysis visualizes outcomes based on author names and their affiliated organizations. The output from VOSviewer resulted in three visual displays: network, overlay, and density visualization.

RESULTS

Based on the Scopus advanced search using the keywords "hospital," "disasters," and "preparedness", 145 articles were retrieved spanning from 2019 to 2023. There appears to be an increasing trend in research articles focused on the evaluation of hospital preparedness for disasters. However, there was a decline in the number of studies in the year 2020. After obtaining the metadata from Scopus, the data was saved in the RIS file format. This RIS format was subsequently utilized and analyzed using the VOSviewer application. The result from the analysis is discussed in this section.

Result analysis based on Scopus analytics

The dataset showcases the distribution of scholarly documents across different countries or territories, summing up to a total of 145 documents (Fig. 2). The United States leads the list with the highest document count, contributing 45 documents, signifying a substantial presence in this field of study or research. Following behind are Iran, Australia, and South Korea, each contributing 20, 9, and 9 documents, respectively, suggesting a diverse geographical representation in scholarly output. Additionally, countries like China and Ethiopia show moderate contributions with 8 documents each. Meanwhile, Saudi Arabia and Sweden present a smaller yet noticeable presence with 7 documents each, and Indonesia presents
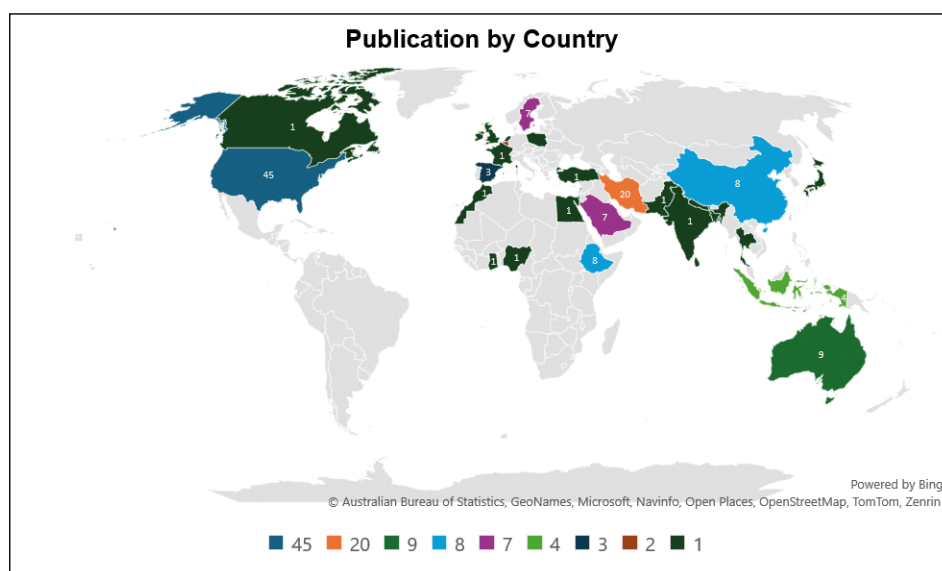
FIGURE 2. Documents by country

4 documents on this research topic. The remaining documents, until reaching a total of 145, are attributed to several other countries or territories not explicitly listed, indicating a global engagement in research activities within the context of this dataset. This distribution sheds light on the varying degrees of research output across different nations, showcasing their participation and contributions to this field of hospital preparedness for disasters study.

Search using the keywords "hospital," "disasters," and "preparedness". The dataset provided illustrates the publication output across five consecutive years in Figure 3, from 2019 to 2023. The data reveals fluctuations in the number of articles released annually within this timeframe illustrated by a bold blue line, but the trendline shown by the blue dashed line shows an uptrend year by year. In 2019, there were 18 articles published, followed by a notable increase to 22 articles in 2020 and 40 articles in 2021 as a peak (Fig. 3). Subsequently, the publication count dropped to 33 in 2023. However, the following year, 2023, experienced constant numbers in publications with 31 articles. This dataset offers insights into the varying levels of research output, potentially indicating shifts in research focus, productivity, or interest within the field under study during these specific years. Analyzing such trends might unveil patterns or periods of intensified academic activity.

The research output showcased an increasing trend in publications addressing the evaluation of hospital preparedness for disasters, indicating a growing interest and concern in this critical area. Despite a slight decline in research output observed in 2020, likely influenced by the onset of the COVID-19 pandemic, subsequent years witnessed a resurgence in publications, highlighting the resilience and adaptability of the research community in addressing emergent challenges.

Two authors, namely Khankeh, H.R., and Abbasabadi-Arab from Iran, each have three documents attributed to their names, as shown in Figure 4A. This indicates a substantial presence and contribution within the field of "hospital," "disasters," and "preparedness." Additionally, Arcos González, P. from Spain, Hart, A. & Ciottone, G.R. from the United States, Dadkhah, B. from India, and others have two documents each associated with their authorship, also illustrated in Figure 4A. This suggests a moderate but noteworthy level of involve-
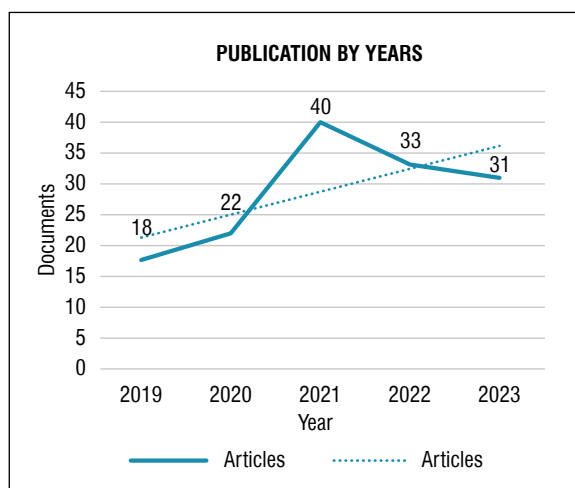
FIGURE 3. Documents by year

ment in the publications related to the aforementioned keywords.

An analysis of the affiliations of the authors using Scopus data shows that Chung-Ang University has the most publications related to the topic, with five documents (Fig. 4B). Iran University of Medical Sciences also has five publications. Other universities with a significant number of publications (four documents each) are Harvard Medical School, Icahn School of Medicine at Mount Sinai, Beth Israel Deaconess Medical Center, and the University of Social Welfare and Rehabilitation Sciences. These data indicate that these affiliations are actively producing publications related to the topic keywords "hospital," "disasters," and "preparedness."

Result analysis based on VOSviewer

The results from the VOSviewer analysis reveal four main clusters grouping closely related keywords or topics within the domain of health research and hospital disaster preparedness. The cluster item group can be seen in Table 1. The first cluster highlights topics related to disaster preparedness and pandemics, encompassing terms such as COVID-19, pandemic, and epidemiology, along with healthcare-related aspects in hospitals. Meanwhile, the second cluster shows a strong association between disaster preparedness and emergency response training in healthcare, including terms like disaster planning, and disaster management, and their association with nurses in multicenter studies. The third cluster focuses on emergency management and healthcare services in response to disasters,
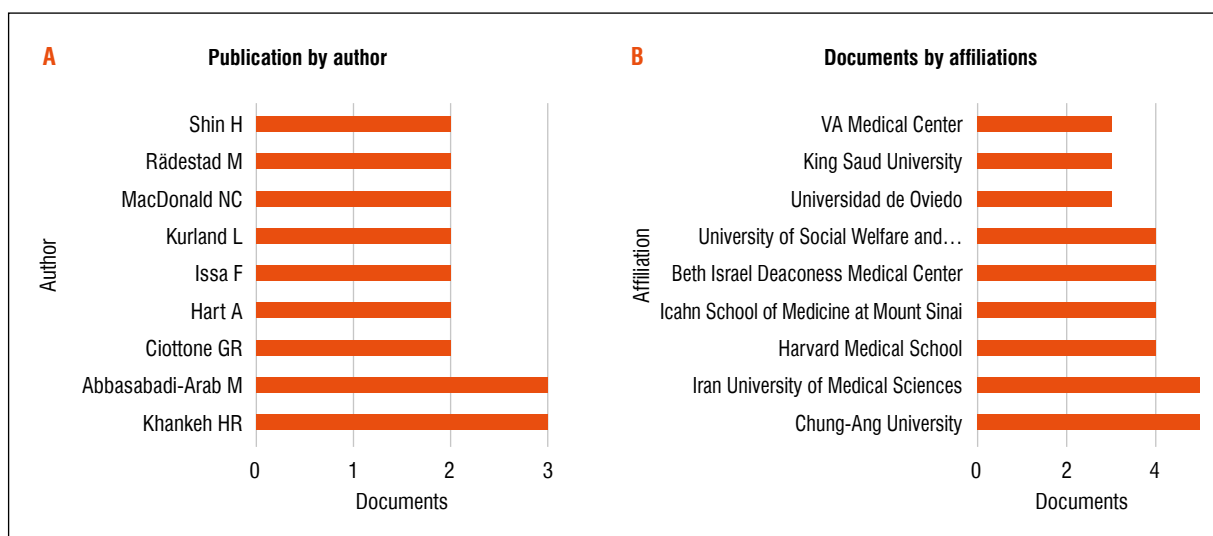
FIGURE 4. Result analysis based on Scopus analytics: **A** — by author, **B** — by affiliation

Table 1. Cluster item group			
Cluster Theme	Items	Total	Percentage
Cluster 1 "Healthcare system and pandemic preparedness"	Aged, COVID-19, disaster preparedness, epidemic, epidemiology, follow-up, government, health care facility, health care personnel, health care planning, health care policy, health care system, health personnel, hospital, hospital patient, hospital personnel, intensive care unit, leadership, manager, pandemic, prevention and control, public health, risk assessment, surge capacity	24	31.57%
Cluster 2 "Disaster preparedness and emergency response training in healthcare"	Awareness, clinical article, curriculum, disaster, disaster management, disaster medicine, disaster planning, education, emergency medical services, emergency nursing, exercise, human experiment, knowledge, nurse, preparedness, public hospital, registered nurse, simulation, skill	19	25.00%
Cluster 3 "Emergency management and healthcare services in response to disasters"	Civil defense, disaster response, emergency, emergency care, emergency health service, emergency medicine, emergency preparedness, emergency ward, hospital emergency service, hospital pharmacy, mass casualty incidents, mass disaster, mental health, patient care, pharmacist, pharmacy, practice guideline, simulation training	18	23.68%
Cluster 4 "Disaster response and management in nursing and healthcare settings"	Clinical competence, disaster nursing, earthquake, emergency department, health personnel attitude, natural disaster, nurse attitude, nurse's role, nursing, nursing education, nursing staff, organization and management, procedures, psychology, workforce	15	19.75%

featuring terms such as emergency preparedness, practice guideline, simulation training, and mass disaster, mental health, patient care, focusing on the management of healthcare services during disaster conditions. The fourth cluster, disaster response and management in nursing and healthcare settings contains words like clinical competence and disaster nursing related to the keywords earthquake and natural disaster. This cluster highlights the importance of health workforce competence when facing disaster conditions such as earthquakes or other natural disasters. This cluster analysis demonstrates robust thematic interconnections between pandemic--related topics. "healthcare system and pandemic preparedness" intersects with "emergency management and healthcare services in response to disasters" to address comprehensive healthcare strategies for managing pandemics and emergencies due to natural disasters.

Figure 5 depicts the visualization outcomes utilizing VOSviewer subsequent to the author's execution of keyword inclusion (sorting keywords relevant to the evaluation of hospital preparedness for disasters) and exclusion (filtering out data irrelevant to the
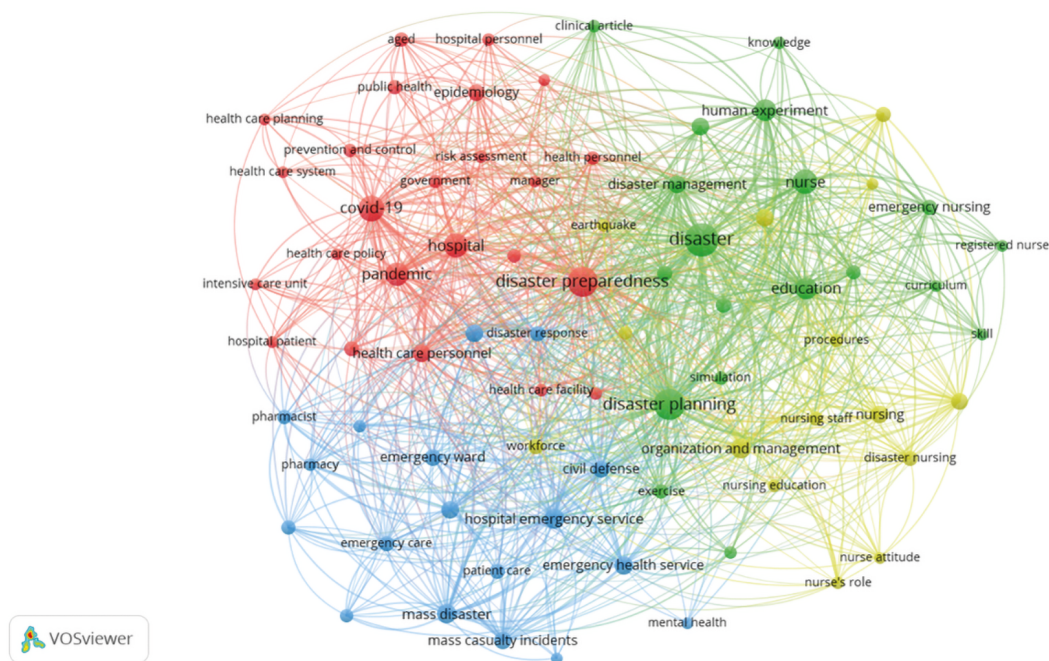
FIGURE 5. Network visualization on hospital disaster preparedness using VOSviewer

evaluation of hospital preparedness for disasters). The resulting visualization has mapped keyword clusters into four distinct groups, denoted by red, green, blue, and yellow colors.

The VOSviewer analysis reveals the relationship between Cluster 1, represented by the red color, and Cluster 2, depicted in green. The correlation observed is pertinent to the subject investigated in the bibliometric analysis, namely the evaluation of hospital preparedness for disasters. The items "nursing", "pharmacist", and "manager" are associated with Workforce or as representatives of medical personnel and are linked to disaster preparedness. The human factor as a mitigator in disaster preparedness emerges as a rational finding. Additionally, the presence of "disaster planning" associated with "disaster" and "hospital" signifies the connection between research focusing on disaster planning and studies involving diverse fields related to hospital emergency health service. Within the navy-blue Cluster 3, the item "hospital emergency service" and Cluster 4 (yellow) with the item "organization and management" is a focal point in this bibliometric analysis.

In Figure 6, it is evident that certain words or topics are depicted prominently and boldly colored, signifying their dominance in discussing themes or past research related to the evaluation of hospital preparedness for disasters. The standout top-

ics include 1) disaster preparedness; 2) disaster; 3) disaster planning; 4) hospital; 5) pandemics and COVID-19. Figure 7 describes the frequently occurring keywords between 2020 and 2022, analyzing research data using VOSviewer.

DISCUSSION
Result analysis based on Scopus analytics

Griebe et al. [22] from the United States show a perspective that disaster is not only caused by natural factors but also by human activity that could cause catastrophes, the uniqueness of this research lies in the development and execution of a "person with a weapon" exercise specifically tailored to the hospital pharmacy department, representing an innovative step in strengthening hospital preparedness for disasters, including terrorism threats. Another research at a midwestern suburban hospital in the United States by Shostrand et al. [23], knowledge deficits in disaster preparedness among hospital-based nurses and healthcare professionals can be enhanced by experiential learning programs. There is a significant improvement in disaster preparedness familiarity on the subject after experiential learning intervention.

Focus research on hospital disaster preparedness also focused topic in Iran, Abbasabadi-Arab et al. [24],
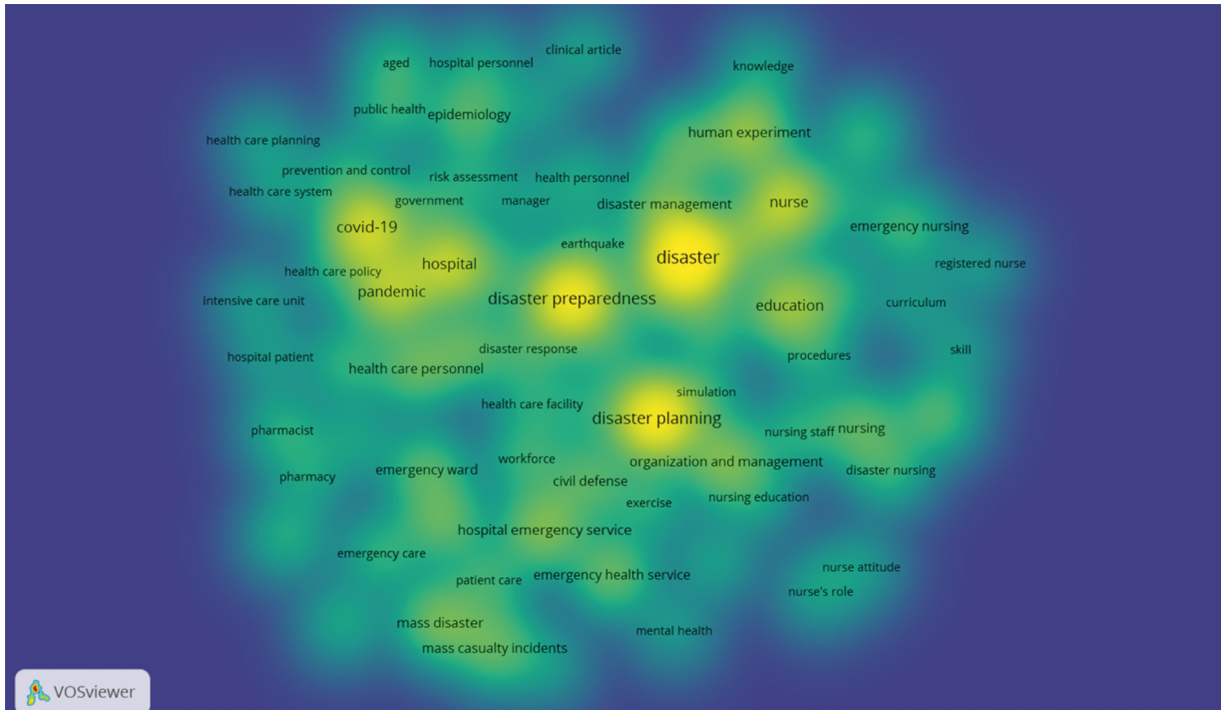
FIGURE 6. Density visualization on hospital disaster preparedness using VOSviewer
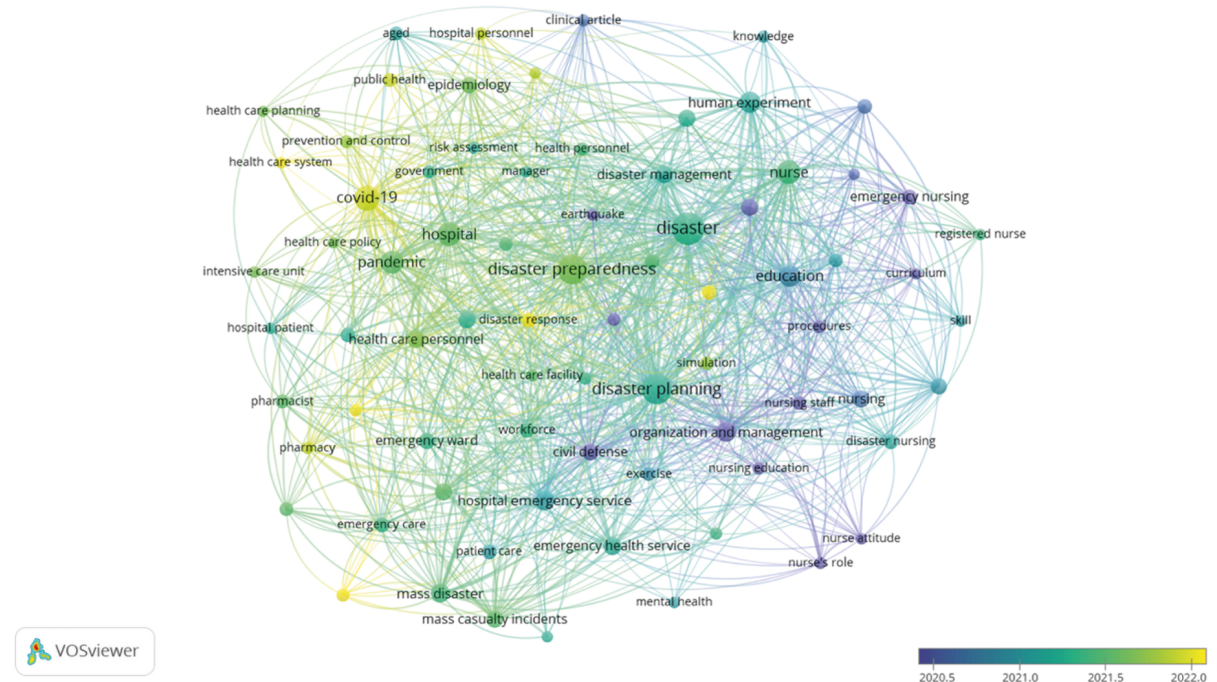
FIGURE 7. Overlay visualization on hospital disaster preparedness using VOSviewer

demonstrate a significant increase in the Hospital Safety Index (HSI) in Iranian hospitals in 2020 (60.84%) compared to 2014 (42%), albeit still moderate. Utilizing the Farsi Hospital Safety Index (FHSI) checklist and a cross-sectional approach in-

volving 604 hospitals, it unveils solutions to fortify hospital safety and preparedness through enhancements in structural, non-structural, and functional safety, alongside managerial skills. The study in Ardabil Province, Iran, found that only a few hospitals

were well-prepared, while most showed moderate readiness levels. Identified areas for improvement include triage, human resource management, and post-disaster recovery. This emphasizes the need for comprehensive planning and clear instructions to bolster hospital readiness for unforeseen accidents, thus contributing to disaster management discussions in healthcare settings [24].

Research topic related to hospital disaster preparedness during the COVID-19 outbreak in China has been done by Hou et al. [25]. This research highlights deficiencies that were identified in multidisciplinary collaboration and efforts to promptly diagnose and treat critically ill patients with fever. These findings underscore the importance of comprehensive preparedness strategies and highlight the need for improved collaboration and rapid response protocols in emergency departments during public health emergencies. The study by Sari et al. [26] examines the demographic characteristics, clinical outcomes, and injuries of earthquake victims admitted to the emergency department within the first week following an earthquake in Diyarbakir, Türkiye. Most victims sought emergency services within three days of the disaster, with a notable percentage transferred from other affected cities. Although the majority of victims were admitted as survivors, a significant proportion were found deceased under rubble. Extremity injuries were prevalent among survivors, with varying treatment needs observed across age groups. These findings underscore the importance of understanding such characteristics and outcomes to inform disaster response strategies of earthquake patients related to preparedness, response, and recovery policies for future disasters.

Meanwhile, there are four research found in Indonesia about hospital disaster preparedness. Research in Indonesia on disaster preparedness encompasses various aspects, ranging from understanding emergency preparedness information among emergency and intensive care nurses to exploring nurses' perceptions of disaster preparedness competencies, evaluating the level of disaster preparedness assessment among emergency nurses, and analyzing the relationship between nurses' perceptions of hospital facility support and disaster preparedness. Findings indicate that factors such as education, disaster simulation experience, awareness of hospital disaster plans, and hospital infrastructure support influence nurses' perceptions and preparedness in facing disasters. In this context, emphasis on understanding, competency, assessment, and hospital infrastructure support constitutes the primary focus of disaster preparedness research in Indonesia [27–30].

The Scopus analysis outcome (Fig. 4) presents the distribution of documents categorized by the number of publications by authors and institutions. A Scopus analysis using the keywords "hospital," "disaster," and "preparedness" reveals interesting trends. Nursing dominates the field with 101 documents, reflecting their critical role in disaster response. Medicine follows closely (74 documents), likely focusing on broader hospital preparedness strategies. Other healthcare professions (38 documents) and social sciences (25 documents) contribute significantly, exploring human factors and community readiness alongside patient care. Emerging fields like engineering (12 documents) and multidisciplinary research (12 documents) point towards a growing focus on hospital infrastructure and collaborative approaches. Overall, the data suggests a strong emphasis on patient care but highlights the need for a more multidisciplinary approach encompassing social impact, mental health support, and infrastructure resilience. Exploring trends and specific research topics within each field can offer further insights to strengthen hospital preparedness across all relevant areas. This distribution delineates the diverse array of subjects investigated within the analyzed literature about the evaluation of hospital preparedness for disasters, portraying the spectrum of academic disciplines encapsulated within this dataset.

In conclusion, the dataset reflects a global engagement in research activities related to hospital preparedness for disasters, with significant contributions from various countries and territories. The analysis highlights the importance of continuous evaluation and improvement of disaster preparedness strategies to enhance healthcare system resilience. Furthermore, the findings underscore the critical role of healthcare professionals, particularly nurses, in disaster response and patient care. By leveraging insights from this comprehensive analysis, policymakers, and healthcare stakeholders can develop more effective strategies to mitigate the impact of disasters on public health and ensure the readiness of healthcare systems to respond to future challenges.

Result analysis based on VOSviewer

Cluster 1 emphasized the importance of healthcare system resilience and pandemic preparedness, underscoring the need for comprehensive strategies to manage pandemics and emergencies. The most related article representing Cluster 1 is Hou et al. [25], who conducted a study on hospital disaster preparedness during the COVID-19 outbreak in China, which revealed shortcomings in multidisciplinary cooperation and the swift diagnosis and treatment of severely ill patients with fever. These results emphasize the necessity of comprehensive readiness plans and stress the importance of enhanced collaboration and quick-response protocols in emergency departments during public health crises.

Cluster 2 focused on disaster preparedness and emergency response training in healthcare, highlighting the critical role of training programs in enhancing healthcare professionals' preparedness and response capabilities. Most of the studies related to Cluster 2 represented by four studies conducted in Indonesia have examined hospital disaster preparedness. They cover various aspects, including understanding emergency preparedness among nurses, evaluating disaster preparedness competencies, assessing emergency nurses' readiness, and exploring the relationship between nurses' perceptions and hospital infrastructure support. These studies highlight the significance of education, disaster simulation experience, awareness of hospital disaster plans, and hospital infrastructure support in shaping nurses' preparedness for disasters. Overall, disaster preparedness research in Indonesia emphasizes enhancing understanding, competency, assessment, and infrastructure support [27–30].

Cluster 3 highlighted emergency management and healthcare services in response to disasters, emphasizing the importance of effective emergency preparedness, practice guidelines, and simulation training in managing healthcare services during crises. There are three studies highlight the necessity of disaster preparedness in healthcare systems related to Cluster 3, as demonstrated by the development of simulation models to evaluate emergency plans during floods [31], the identification of varying levels of disaster core competencies among Turkish nurses [32], and the call for improved disaster training programs to address competency gaps among nurses [9].

Cluster 4 underscored the significance of disaster response and management in nursing and healthcare settings, emphasizing the role of clinical competence, workforce readiness, and organizational management in mitigating the impacts of disasters. Research by Lin et al. [33] investigates factors associated with readiness for disaster response among Taiwanese hospital nurses, revealing that length of nursing work, higher education level, working in intensive care units or emergency rooms, and previous disaster training are positively associated with nurses' readiness for disaster responses. These findings underscore the importance of considering these determinants in recruiting nurses for disaster response assistance and designing tailored disaster training programs for nurses in the future. Bahranifard et al. [34] suggest the need for practical measures such as crisis management courses, establishment of a crisis management team, resource estimation, structural changes, human resource provision, equipment maintenance, timely triage, and hospital retrofitting to enhance preparedness. Jamaili et al. [35] state that nurses with their technical skills and practical knowledge can provide the highest level of disaster care appropriate to adverse conditions to improve the health of those affected.

The concept of hospital preparedness for disasters is notably characterized by the term "nurse", and serves as the primary subject in disaster preparedness [36]. This term holds significant influence over the discussed topics, resulting in its frequent usage by researchers in creating published articles, aligning with the subsequent research focus. Concerning "education", "hospital emergency service", and "clinical competence" serve as complementary topics that align with the theme, mutually reinforcing the dominant concept, and vice versa.

One of the reviewed studies mentioned that through an anonymous survey involving 134 healthcare providers, their self-assessment indicated a better perception regarding personal readiness compared to their workplace readiness in facing disaster events. This evaluation serves as a valuable tool to identify and rectify potential gaps and weaknesses in the functioning and management of hospitals during mass incidents [37]. The keywords "risk management" and "evaluation" were identified to appear in the research titled Developing a hospital disaster risk management evaluation model [15]. The keyword "evacuation" appears in the research titled Evacuation from healthcare facilities in Poland: legal preparedness and preparation [38].

Based on Figure 7, in the year 2020, the data indicates that "organization and management" emerged as a prominent keyword, suggesting that research on hospital disaster preparedness focused on organizational and management variables during that time [34, 39]. In contrast, in 2021, the keywords were more varied and centered around "disaster planning". Subsequently, in the following year, the focus shifted towards the topic of "disaster preparedness" [40, 41]. Publications in 2022 predominantly focused on keywords related to "COVID--19". This indicates a positive trend, reflecting a concern for evaluating hospital readiness for disasters, including pandemics, in the upcoming future [42–44].

The analysis also revealed temporal shifts in research focus, with keywords such as "organization and management" dominating in 2020, followed by a transition to "disaster planning" in 2021, and a subsequent emphasis on "disaster preparedness" in 2022. This temporal evolution reflects the dynamic nature of disaster research and the need for continuous adaptation and response to emerging threats and challenges.

The analysis of journal articles from 2019 to 2023 reveals significant advancements in hospital disaster preparedness research, driven by increased publications following the COVID-19 pandemic. This period highlights four main thematic clusters: healthcare system resilience, training programs, emergency management, and disaster response in nursing and healthcare settings. The VOSviewer analysis further illuminates these themes, showing strong interconnections and temporal trends. The clustering of keywords underscores the multifaceted nature of disaster preparedness, from pandemic response to emergency management and workforce competence. These visualizations emphasize the importance of comprehensive strategies, effective training programs, and the need for continuous adaptation to emerging threats.

Key findings underscore the critical role of integrating organizational management, strategic planning, and community resilience into disaster preparedness frameworks. Studies by Firissa et al. [45] and Chisholm et al. [46] highlight the necessity of robust disaster plans, regular training, and effective communication networks. Aminizadeh et al. [47] also emphasize the need for standardized instruments with reliable psychometric properties for assessing hospital preparedness in biological events.

Geographically, the United States leads in publication volume, with significant contributions from Iran, Australia, South Korea, China, and Ethiopia, reflecting diverse approaches and challenges in disaster preparedness. Institutions such as Chung-Ang University and Iran University of Medical Sciences have notably contributed to developing measurement tools and evaluation policies.

Regarding subject areas, nursing dominates with a focus on medical personnel preparedness and training, while medicine addresses broader hospital strategies. Other healthcare professions and social sciences also contribute significantly, covering mental readiness and psychosocial support.

Future research should focus on integrating various healthcare professionals into disaster preparedness training, conducting longitudinal studies on training effectiveness, and developing adaptable frameworks for different settings. Exploring technological innovations and preparing for climate-related disasters is crucial for enhancing hospital preparedness. Effective communication, regular restocking of supplies, and community engagement are essential components that require ongoing evaluation to ensure a resilient healthcare system.

Acknowledging the study's limitations is essential, as it relies solely on data from the Scopus database. Future studies should incorporate data from additional databases to provide a more comprehensive understanding of hospital disaster preparedness and enrich the research perspectives in this critical area.

CONSLUSIONS

The research indicates a growing interest in evaluating hospital preparedness for disasters, with a resurgence in publications following the initial impact of the COVID-19 pandemic. Four main thematic clusters emerged, emphasizing healthcare system resilience, training programs, emergency management, and disaster response in nursing and healthcare settings. Temporal shifts in research focus were observed, reflecting the dynamic nature of disaster research. The findings underscore the critical importance of comprehensive strategies to manage pandemics and emergencies, enhance preparedness through training programs, and improve emergency management practices. By leveraging insights from this analysis, researchers and policymakers can enhance healthcare system resilience and effectively respond to disasters to safeguard public health.

Article information and declarations

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REVIEW PAPER

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VIA MEDICA

ARTIFICIAL INTELLIGENCE FOR THE PREDICTION OF HEALTH EMERGENCIES AND DISASTERS

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ABSTRACT

Amidst unprecedented global health challenges, exemplified by the recent SARS-CoV-2 pandemic and other natural disasters, the imperative for initiative-taking measures is evident. Resilient health systems, initiated by Pan American Health Organization/World Health Organization (PAHO/WHO), seeks to fortify preparedness. This study explores the pivotal role of artificial intelligence (AI) advancements in addressing health crises. A scoping review was conducted on PubMed, Scopus, and LILACS databases. Limited to 2013––2024. Inclusion criteria: freely accessible articles in Spanish, English, or Portuguese on AI in disaster prediction and management. Removed duplicates and irrelevant languages. Subjective selection based on abstract and title. Grouped articles into two categories. Key information was extracted for analysis. Findings underscore the need for targeted exploration in AI applications for epidemic prediction. Ongoing exploration is evident, with a particular emphasis on specific symptom-based predictions. Beyond epidemics, AI excels in predicting a spectrum of natural disasters globally, from sea-level changes to earthquakes. Noteworthy successes include cyclone and flood predictions. Challenges, such as real-time updates, regional complexities, and global communication, must be addressed for widespread adoption. AI is a pivotal force in transforming healthcare and disaster management. The path forward involves a cohesive integration of technological innovation, ethical considerations, and global cooperation to fully unleash the benefits of AI for public health.

KEYWORDS: artificial intelligence; forecasting; disaster management; health policy; disaster medicine

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INTRODUCTION

Throughout history, humanity has faced multiple catastrophic events and epidemics, each precipitating profound consequences on a global health scale. The most recent crisis, triggered by SARS-CoV-2, resulted in a worldwide quarantine, imposing diverse socioeconomic implications in addition to the well-documented health impacts [1]. Beyond the recent pandemic, the global population has faced other formidable challenges, giving rise to repercussions comparable to those experienced in the tumultuous year of 2020. Notable instances encompass the Spanish flu and the ongoing human immunodeficiency viruses (HIV) pandemic, affecting a persistent and staggering number of over thirty-one million people to date [2]. Additionally, health emergencies generated

by natural disasters such as the earthquakes in Haiti and Chile in 2010, or hurricane Dorian in 2019, must be mentioned. These events have had even greater repercussions than the previously mentioned pandemics [3].

The multifaceted repercussions of health emergencies, as exemplified by those mentioned earlier, are evident. Consequently, a segment of the global health system has directed its efforts towards averting these epidemiological events, culminating in the designation of December 27 as the International Day of Epidemic Preparedness [4]. The Pan American Health Organization/World Health Organization (PAHO/WHO) has set specific goals for the year 2025, based on the number of countries capable of preventing and controlling epidemics or pandemics of significant magnitude [5]. This highlights how major health organizations have focused their attention on the prevention of health emergencies.

In this context, it is important to mention resilient health systems, a strategy led by the PAHO, established in September 2020 in response to the SARS-CoV-2 pandemic [6]. A resilient health system is equipped to manage any health emergency or disaster, demonstrating the capacity to anticipate and effectively respond. These systems are further distinguished by their emphasis on health promotion and prevention, coupled with expansive population coverage and other essential features. Considering these attributes, one might contemplate the potential impact of a technological tool capable of supporting resilient health systems or guiding developing countries in reshaping their healthcare infrastructure to enhance resilience [7].

In recent years, artificial intelligence (AI) has become a topic of interest, as its application in various fields, along with its multiple tools, has been a significant advancement for humanity (Tab. 1).

Table 1. AI's terminology; adapted from reference [8]	
Artificial Intelligence (AI)	Definition
Deep learning	A subset of machine learning that utilizes deep neural networks to model complex patterns in large datasets. These networks have multiple layers that progressively extract higher-level features from raw input. Applications include speech recognition, image classification, and natural language processing
Neural networks	Computational models inspired by the human brain, consisting of interconnected nodes (neurons) that work in unison to solve specific problems. These networks learn from data by adjusting the weights of connections based on the error of predictions. Neural networks are the foundation for various deep-learning models
Feedforward neural networks	The simplest type of artificial neural network where information flows in one direction, from input to output, without any cycles or loops. They are typically used for tasks like classification and regression. Each neuron in a layer is connected to every neuron in the previous and next layer
Recurrent neural networks	A type of neural network where connections between nodes form a directed graph along a sequence, allowing them to maintain information in "memory" over time. This makes RNNs particularly effective for sequential data such as time series, language modeling, and speech recognition
Convolutional neural networks	Specialized neural networks designed for processing structured grid data like images. They use convolutional layers to apply filters that capture spatial hierarchies, pooling layers to reduce dimensionality, and fully connected layers for classification. CNNs are widely used in computer vision tasks such as object detection and image segmentation
Case-based reasoning	A method in artificial intelligence where a system solves new problems based on the solutions of similar past problems. It involves four steps: retrieving a case similar to the current problem, reusing the case to solve the problem, revising the proposed solution if necessary, and retaining the new solution as part of a new case. This approach is useful in domains where rules are hard to define but examples are plentiful
Information retrieval	The process of obtaining relevant information from a large repository (such as a database or the internet) in response to a user's query. IR systems use algorithms to rank and return the most relevant documents or data. Techniques include keyword matching, natural language processing, and semantic search. Applications range from search engines to recommendation systems

AI — artificial intelligence

Likewise, Big Data, which refers to an amount of information so large surpassing the processing capacity of traditional methods, has been intricately intertwined with the progress of AI, thereby augmenting the capabilities of AI itself [8]. Therefore, this article aims to analyze the available evidence regarding the use of AI in addressing health emergencies and disasters.

MATERIAL AND METHODS

A scoping review was conducted on online databases such as PubMed, Scopus, and LILACS, in search of answering the question: What application has been given to AI in the prediction of health emergencies and disasters? Considering that health emergencies and disasters are defined as those that put the local health system at maximum capacity due to the occurrence of a natural disaster or an epidemic. The literature review did not include "gray literature" or non-indexed databases, by the choice of the authors. *Descriptores en ciencias de la salud* (DeCS) and medical subject headings (MeSH) terms such as "artificial intelligence", "forecasting" and "disaster management" were used in Spanish, English, and Portuguese. Only a date filter was applied in the Scopus database, limiting literature to the period from 2013 to April 2024, because in this database the literature found was extensive, making a proper review impossible, so a date filter reduced it to a more accessible sample.

The inclusion criteria were freely accessible articles published in Spanish, English, or Portuguese that addressed topics such as natural disasters, epidemics, or structural failures and their prediction and management through AI. That is, this document not only focused on the prevention and mitigation stage but also included articles that implemented AI in the response and recovery of health emergencies. Duplicate articles and those not in Spanish, English, or Portuguese were removed. A subjective selection was made based on the abstract and title, and the selected articles were obtained through the library of the Universidad de La Sabana and saved in an online storage cloud for easy access by all authors. Key information such as authors, title, authors' country, year of publication, and main ideas were extracted from each article (Tab. 2).

Lastly, the articles were grouped into two categories; each article was read by each member of the research group, extracting main ideas which includ-
ed AI applications in the previously mentioned topics of interest, important figures found in the results of these applications, barriers during implementation, among other data; subsequently, the joint writing of the information found was carried out. Additionally, for each article deemed suitable for study, an additional literature search was conducted on their references using the "snowball" method, applying the inclusion criteria previously described.

RESULTS

146 articles were found in the mentioned online databases, three of those were duplicated and nine were written in Chinese. The remaining 134 articles were filtered by title and abstract, deleting 120 articles that did not include artificial intelligence use or use of AI for prediction, besides not related to the main topic or not being free access. Finally, fourteen articles and five from the "snowball" method were downloaded for a complete review by the research group and divided into two groups: 1) artificial intelligence for epidemic prediction (6 articles), and 2) artificial intelligence for natural disaster prediction (13 articles) (Fig. 1).

Artificial intelligence for epidemic prediction

Presently, there is AI specifically designed to detect symptoms during outbreaks, epidemics, or pandemics. For example, some AI systems can extract information from social media during public health disasters, offering the health sector a valuable tool for epidemiologic surveillance, by extracting extensive amounts of health-related data from various online sources, such as Twitter, to monitor and keep tabs on the emergence of infectious diseases, including influenza. An example of this was during hurricane Sandy, where more than 20 million Twitter posts (tweets) were generated in one week, helping US response teams filter relevant signals [9]. Nevertheless, it is essential to emphasize the necessity for specificity in information extraction, behavior mining, and real-time analytics customized for health situational awareness. This specificity is crucial for enabling a global response during disasters [9]. An AI similar was developed in Germany and Italy; In Germany, the focus was on two well-known social networks and their exclusive forums for reporting symptoms related to COVID-19; This AI was able to predict cases of COVID-19, depending on the symptoms reported, model performance

Table 2. Articles were finally included in the study; source — author´s work

Author	Title	Country	Year	Summary
Artificial intelligence for epidemic prediction				
Jennifer L. Chan et al. [9]	Challenges to transforming unconventional social media data into actionable knowledge for public health systems during disasters	United States	2020	Data collection through social networks requires an improvement in AI currently available
Francesco Bellocchio et al. [10]	Enhanced sentinel surveillance system for COVID-19 outbreak prediction in a large european dialysis clinics network	Italy	2021	The developed sentinel can predict new COVID-19 outbreaks
Domenic Kellner et al. [11]	Improved healthcare disaster decision-making utilizing information extraction from complementary social media data during the COVID-19 pandemic	Germany	2023	The AI showed being capable of predicting the number of COVID-19 cases from Twitter and Reddit user's posts
Caitlin Monaghan et al. [12]	Machine learning for prediction of patients on hemodialysis with an undetected SARS-CoV-2 infection	United States	2021	An AI capable of predicting a patient in hemodialysis suffering from COVID-19 three days before the clinician
Zifeng Yang et al. [13]	Modified SEIR and AI prediction of the epidemic trend of COVID-19 in China under public health interventions	China	2020	A combined AI with a tool of epidemic surveillance predicted new peaks of COVID-19
C. Tsatsoulis et al. [14]	Finding clusters of similar events within clinical incident reports: a novel methodology combining case based reasoning and information retrieval	United States	2003	The AI can identify similar cases but has a low accuracy in doing it
Artificial intelligence for natural disaster prediction				
Ahmed Alshouny et al. [15]	An integrated framework for improving sea level variation prediction based on the integration wavelet-artificial intelligence approaches	Saudi Arabia	2022	There are many AIs for the prediction of sea level rise, but they have failed, cause they don't take into account some variables like climatic change
Xing Huang et al. [16]	Application of improved ELM algorithm in the prediction of earthquake casualties	China	2020	The updated model has higher stability and good prediction accuracy for the earthquake casualty
Muhammet Gul et al. [17]	An artificial neural network-based earthquake casualty estimation model for Istanbul city	Türkiye	2016	An artificial neural network can reveal an accurate estimation of casualties in earthquake disasters
Xing Huang et al. [18]	The casualty prediction of earthquake disaster based on the extreme learning machine method	China	2020	Improved casualty prediction in earthquakes by an AI based on machine learning
Jooho Kim et al. [19]	A framework to predict community risk from severe weather threats using probabilistic hazard information (PHI)	United States	2023	The AI is limited by the minute-to-minute changes that suffer the weather; more studies are still needed
Vai-Kei Ian et al. [20]	Assessing the risk of extreme storm surges from tropical cyclones under climate change using bidirectional attention-based LSTM for improved prediction	China	2023	This AI has new upgrades that improve the prediction accuracy of sea water level anomalies during storm surges, regardless of the temporal dynamics
C. Purna Chand et al. [21]	Predicting Indian Ocean cyclone parameters using an artificial intelligence technique	India	2022	The AI created can predict cyclones but has low precision, and is not much different from the method currently used
Fahad Ahmed et al. [22]	Comparison of different artificial intelligence techniques to predict floods in Jhelum river, Pakistan	Pakistan	2022	There is an AI that can predict floods in the mentioned region, but it needs more work to be used in other countries too

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Table 2. (cont.) Articles were finally included in the study; source — author´s work				
Artificial intelligence for natural disaster prediction				
Author	Title	Country	Year	Summary
Sara Saravi et al. [23]	Use of artificial intelligence to improve resilience and preparedness against adverse flood events	United Kingdom	2019	Presents current AI for the classification and forecast of flood events, with good accuracy
Naruephorn Tengtrairat et al. [24]	Automated landslide-risk prediction using web GIS and machine learning models	Thailand	2021	This AI is capable of forecasting landslide risk in Thailand's cities
Seth Guikema [25]	Artificial intelligence for natural hazards risk analysis: potential, challenges, and research needs	United States	2020	Using AI to manage natural hazards is the future, but it is important to take care of false confidence
Monique M. Kuglitsch et al. [26]	Facilitating the adoption of AI in natural disaster management through collaboration	Germany	2022	The AI currently available is a great tool, the demanding thing is its adoption by the corresponding entities
Sally Lu et al. [27]	Applications of artificial intelligence and machine learning in disasters and public health emergencies	United States	2021	A review of literature was conducted in search of AI pertaining to disasters and public health emergencies
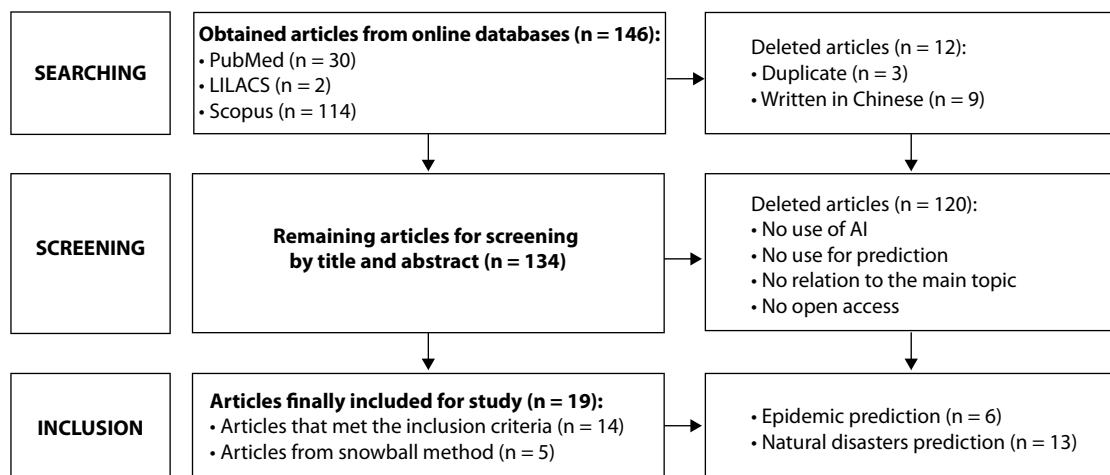
FIGURE 1. Searching method; source — author´s work

was adequate across all testing windows: Area under the curve (AUC) was 0.77, 0.80, and 0.81, respectively [10]. In Italy, the basis for predicting potential COVID-19 symptoms among patients was drawn from a network of dialysis clinics; using AI, the system demonstrated that predictions lead to official COVID-19 incidences by up to 14 days in this population [11].

Similarly, in the United States, an AI based on machine learning was created that could predict the risk of COVID-19 in hemodialysis patients. Through 81 variables and based on data from a national network of dialysis clinics, a cohort of 40,490 patients (about twice the seating capacity of Madison Square Garden) was reached (11,166 with positive tests for

COVID-19 and 29,324 who did not). The area under the receiver operating characteristic curve (AUROC) and area under the precision-recall curve (AUPRC) for the model were 0.68 and 0.24 in the testing dataset, respectively. Finally, it was concluded that the AI predicted when a patient was at risk of COVID--19 up to three days before a clinical suspicion was established by the treating service [12].

Likewise, but on a larger scale, China developed an AI in conjunction with a previous model of epidemiological evaluation and control, capable of predicting new epidemics; which showed that at the end of February 2020, there would be a peak of infections with a gradual decline until the end of April, which allowed for rapid action by health authorities,

such as maintaining quarantine for a certain additional period, and through the same AI it was demonstrated that these actions prevented a new epidemiological peak [13].

Additionally, according to a study, the combination of case-based reasoning and information retrieval techniques from the field of AI provides an effective method for identifying clusters of similar incident reports in the medical field. The study suggests that using both techniques together results in better performance in finding clusters of similar medical incident reports compared to using either technique alone. The study also recommends that future systems developed to cluster medical event reports should integrate both the field values and the text of the reports in their methodological approach for improved accuracy and recall [14].

Artificial intelligence for natural disaster prediction

The findings in the study by Alshouny et al. [15] showed that the deep learning neural network (DLNN) model has superior potential compared to machine learning models, increasing the accuracy of SLV prediction by 23%. Furthermore, the developed DLNN model can predict the sea level variation (SLV) for three days with a correlation coefficient of 0.91, which is useful for making early SLV predictions for disaster management purposes [15].

On the earthquake side, the adaptive chaos particle swarm optimization (ACPSO-ELM) algorithm has an R-squared coefficient of 0.96, which is better than other prediction models for the number of earthquake deaths [16]. Furthermore, a study in Türkiye implemented an Artificial Neural Network for earthquake casualty prediction, using predictors such as earthquake occurrence time, earthquake magnitude, and population density, as well as past events, given the country's high frequency of earthquakes. The results show that 99.9% of the variability in the number of injured people is predictable using this model, which can provide accurate estimations of casualties and information to develop mitigation policies [17]. At the same time, in China, a machine learning tool was implemented to increase the prediction of casualties of earthquake disaster accuracy, based on data from 84 groups of earthquake victims in China from 1970 to 2017, a relative error for earthquake disaster prediction of 3.37% was found, which indicates that this AI algorithm has good robustness and generalization ability [18].

One of the initial areas where AI was developed is its ability to predict climate changes and their impact on the population. However, it still requires an interface capable of updating minute by minute due to the climatic variability present in these times [19].

Linked with climate changes and their coastal implications, AI has been developed with the capability to correlate weather patterns to predict the future presence and intensity of cyclones. For instance, the bidirectional attention-based long short-term memory (LSTM) storm surge architecture (BALSSA) model, which employs a bidirectional attention-based architecture for storm surge prediction, was trained and evaluated using a comprehensive dataset encompassing over 70 typhoon incidents in Macau from 2017 to 2022. The results demonstrate the outstanding performance of BALSSA, offering highly accurate storm surge forecasts with a lead time of up to 72 hours [20].

Conventional methods such as artificial neural networks are also used to predict the cyclone's parameters, the position data in terms of latitude and longitude, wind speed, and pressure. The artificial neural network predictions for the land crossing points have a mean error of 38.4 km for the 12 h forecast and 71.02 km for the 24 h forecast [21]. In the aftermath of cyclones, floods become a focal point for AI studies. It highlights the capacity to forecast impending floods by analyzing various geographic variables incorporated during its programming, since the flooding process has a non-linear relationship with various meteorological factors and topographic parameters since the flooding process has a non-linear relationship with various meteorological factors and topographic parameters [22]. These models can bring an accuracy rate of 80.49% [23]. However, the intricate nature of these variables poses a challenge, limiting the applicability of such AI models to other regions [18, 19].

In the same way, in a region of Thailand where large landslides are frequent, the possibility of having AI capable of predicting this phenomenon was studied, showing adequate performance, with an AUC precision of 0.47 and promising prospects for disaster medicine [24]. Some authors agree that the primary challenge with AI in natural disasters lies not in its development but in its communication and global adoption. It necessitates active engagement from those working daily with these tools to collaborate with pertinent governmental entities in formulating policies for global prevention and healthcare [25, 26].

Based on the above, the need for a rapid response to disasters is proposed as an additional application of AI, so machine learning has been used for evacuation simulations during natural disasters, using scenarios that have previously presented these disasters, such as Chile in 2010, obtaining variables that are not normally taken into account and could generate more effective and safe evacuation routes, even in large crowds [27]. Similarly, AI has been adapted for use in other areas, to serve as an early response tool during emergencies, for example, Hierarchical task network planning, which showed adequate results. However, during its adoption, variables that could harm its eventual standardized use were not considered. In turn, new tools have been created with the same objective, demonstrating a faster and more effective response than in previous situations [27].

DISCUSSION

The integration of AI in clinical care has led to significant shifts beyond provider-patient interactions. Four major trends include the evolving role of patients, a transition from hospital to home-based care facilitated by telemedicine, AI extending clinical care beyond formal health systems, and AI's role in resource allocation and prioritization. The evolving patient role involves AI aiding self-management and raising ethical concerns about regulation and patient responsibility. Home-based care is advancing through telemedicine, AI-driven monitoring, and just-in-time adaptive interventions. AI extends clinical care outside traditional health systems, reaching education, workplaces, and social media, necessitating continuous monitoring with wearables, and posing ethical concerns. Lastly, AI assists in resource allocation, particularly during crises like COVID-19, with the potential to optimize critical care decisions and address resource shortages [10–13, 28].

In the realm of AI in health, there is a notable absence of formal procedures for credentialing or licensing technology designers and developers, unlike the stringent requirements for healthcare workers. Mere calls for adherence to abstract moral values are insufficient, necessitating innovative approaches in software engineering. Recent advancements go beyond traditional programming techniques, introducing methods for systematically integrating ethical values into AI technology de-sign. Legal codifications, such as the General Data Protection Regulation, mandate specific obligations like privacy by design. One such approach is "design for values," aligning design with human rights standards, focusing on values like human dignity, freedom, equality, and solidarity as non-functional requirements. This process-oriented paradigm prioritizes stakeholder needs in harmony with moral and social values [25, 26, 28].

Finally, human rights standards, data protection laws, and ethical principles are essential for guiding AI use in health, involving developers, governments, providers, and patients. Stakeholders seek universally accepted ethical principles for AI in health, and the WHO aims to foster consensus with the principles outlined in this report. The challenges posed by AI in health go beyond existing laws and principles, especially as the risks and opportunities are not fully understood and may evolve. Low- and middle-income countries encounter additional challenges, requiring awareness of ethical principles and appropriate governance for implementing new AI technologies. Governance in health involves steering, rule-making, and political processes, aligning with national health policy goals for universal health coverage. WHO's global strategy on digital health, along with other governance frameworks and standards, contributes to establishing a governance framework for AI in health, addressing ethical dimensions in various governance areas [25, 26, 28].

LIMITATIONS

Despite promising advances in the application of artificial intelligence to predict epidemics and natural disasters, this study faces some limitations that must be acknowledged. One of the main limitations is the lack of solid scientific literature in this emerging field. Most of the available studies focus on specific applications and often lack a comprehensive approach that spans various regions and contexts. This lack of data and comparative studies makes it difficult to fully assess the effectiveness and widespread applicability of AI models. Additionally, there is a risk of inherent biases in the data used to train these models, which can affect the accuracy and generalizability of the predictions. Future research should focus on expanding and diversifying the database, to minimize these biases and close existing gaps in the literature.

CONCLUSIONS

This article has explored the role of artificial intelligence in predicting epidemics and natural disasters. On the part of epidemic prediction, it has proven to be a powerful tool in epidemiological surveillance, since AI systems can extract information from social networks and other online sources to monitor and predict the emergence of infectious diseases, as was the case of the COVID-19 pandemic. These systems have demonstrated the ability to anticipate incidents, however, the importance of specificity in information extraction and analysis in real-time is highlighted to obtain an effective global response during emergencies.

AI has also demonstrated its potential in predicting natural disasters, for example, models with high accuracy have been created to predict variations in sea level and the number of deaths from earthquakes. The application of these models may be limited due to the variables involved and the need for interfaces capable of updating in real-time.

Despite advances, there are significant challenges in the global adoption of AI in the context of disasters. It is crucial that AI developers work closely with government entities to formulate global prevention policies. In summary, AI represents an invaluable tool for improving the prediction and management of epidemics and natural disasters, but its effective implementation requires careful consideration of ethical challenges and global collaboration.

Article information and declarations

Conflict of interest
The authors declare no conflict of interest.

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VM VIA MEDICA

LETTER TO THE EDITOR

THE IMPACT OF A DISASTER ON AN EMERGENCY DEPARTMENT DISTANT FROM THE EPICENTER: OUR EMERGENCY MEDICINE PRACTICES

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Dear Editor,
an earthquake is different from other disasters because it affects all living beings in the affected region and requires a multidisciplinary approach [1]. After major earthquakes, large populations migrate to other cities, accompanied by the transfer of injured individuals [2]. As a result of the two consecutive major earthquakes centered, the aftermath affected 11 cities and millions of people [3]. When examining past earthquake experiences, the most common issues encountered are related to identification, patient records, triage, and the proper planning of personnel and equipment [4]. Head, abdominal, and chest trauma are less frequently seen in emergency departments (ED), as they often lead to rapid mortality in the early hours after an earthquake. Consequently, extremity fractures, amputations, compartment syndrome, and rhabdomyolysis — become more prominent in ED [5]. In ED far from the disaster area, while trying to provide urgent medical care to disaster victims, you must also simultaneously attend to other patients arriving at the emergency department. The physical and psychological burden that this places on healthcare personnel is one of the most significant risk factors affecting the delivery of care. The most important source of motivation was their belief that they could provide more help to those being rescued from beneath the rubble.

In this report, we aimed to outline clinical practices used in managing the disaster's aftermath away from the earthquake's epicenter. Within the first 10 days, 2,716 patients presented to the adult ED, with 658 adults and 214 pediatric patients hospitalized. A total of 290 adults and 83 pediatric patients underwent surgery, while 31 adults and 6 children died. It was expected that a large number of patients with simultaneous multi-trauma and crush injuries would arrive, so we planned a rapid triage algorithm and personnel distribution. Exhausted staff were given mandatory rest, and a new shift schedule was created for everyone. In addition, sleep and nutritional needs were regularly monitored. The triage of both adult and pediatric patients was conducted by an experienced emergency medicine specialist. The most important factor that accelerated triage was our effective management of the 28 enclosed patient areas (level 3 critical care) in our critical care unit, where we could simultaneously provide healthcare services to a total of 56 patients. We assigned healthcare personnel, and all necessary medical devices for multi-trauma management to each room. Each healthcare worker received the patients within their designated room. The biggest issue for patients after triage was the lack of identification and medical records. To address this, we took facial photographs of all patients, assigned them a natural disaster diagnosis

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code, and registered each patient in the hospital information system with a unique identification code. Another team worked on recording and storing patients' personal belongings. After the medical evaluation was completed, only the radiology unit next to the critical care area was used for radiological imaging of these patients. Experienced emergency medicine specialists performed FAST ultrasound on the patients, allowing for quick decisions on the placement of central catheters or chest tubes as needed during the initial trauma assessment.

In conclusion, the management of both the primary destructive effects of the earthquake and the subsequent secondary health issues requires careful planning of limited personnel and medical supplies, as well as preparation for potential problems.

Article information and declarations

Author contributions

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Conflict of interest

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LETTER TO THE EDITOR

VIA MEDICA

EVALUATING THE IMPACT OF RAPID DIAGNOSTIC TESTS, VACCINATION, TREATMENT, AND CLIMATE CHANGE ON MALARIA CONTROL IN A CHANGING GLOBAL LANDSCAPE

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Dear Editor,
despite substantial global endeavours and economic investments, malaria continues to be a major obstacle in modern medicine and the most widespread infectious menace worldwide. The latest World Malaria Report (WMR) 2023, an annual publication by the World Health Organization (WHO), reveals that the number of malaria cases in 2022 rose by 5 million compared to 2021. Nevertheless, there was an 11,000 decrease in the number of deaths compared to the previous year, although the current count of 608,000 is still alarmingly high [1]. In this letter, inspired by Chaudhary et al. [2], we highlight new factors and reports that may affect future projections, as well as environmental and pathogen changes that require decisive responses.

Climate change is a major potential threat. Climate changes affect malaria risk in complex ways. Global warming may reduce malaria-carrying *Anopheles* mosquitoes. By reducing mosquito breeding sites, drier seasons, often linked to global warming, reduce malaria transmission. However, recent research highlights the magnitude of the risks associated with this scenario, including the spread of the disease to mountainous regions, shifts in *Anopheles* mosquito distribution, with an increase in South Africa and China but a decrease in India and Southeast Asia, and transmission in highland areas being extended [3]. Climate change increases Plasmodium and *Anopheles* larvae development and reproduction. Furthermore, climate-related disasters and poor sanitation increase malaria incidence and epidemics [4].

Pharmacotherapy and chemoprevention are key malaria treatments, but drug resistance threatens their efficacy. Drug resistance threatens, but vaccines offer hope. WHO has approved two malaria vaccines. In October 2021, WHO recommended RTS,S/AS01 (RTS,S) for the prevention of malaria caused by Plasmodium falciparum in children from 5 months old in moderate to high transmission areas. In 2023, WHO recommended R21/Matrix-M, the second vaccine. Both vaccines are safe and effective. In efficacy studies, RTS,S reduced symptomatic malaria risk by 39% and severe malaria risk by 29%, while

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R21/Matrix-M reduced risk by 75% in countries with high seasonal transmission and 66% in countries with more consistent malaria transmission [5, 6]. Both adjuvant subunit vaccines require three doses and a booster. Given the low availability of RTS,S compared to demand, the introduction of R21 into the medical arsenal could ensure sufficient access to this preventive method for all children living in malaria-endemic areas. The introduction of tafeno-quine has improved malaria chemoprophylaxis and relapse prevention. Tafenoquine, like primaquine, eliminates dormant liver stages (hypnozoites) and prevents relapse, but it is usually combined with chloroquine, which targets blood stages. It can prevent malaria caused by *Plasmodium vivax* or Plasmodium falciparum. Combined with chloroquine, it prevents relapses as well as primaquine. This result was achieved with a single dose of tafenoquine, which is relevant given the challenges of nonadherence to the 14-day primaquine regimen [7, 8].

Advanced malaria detection methods like Rapid Diagnostic Tests (RDTs) have also improved malaria control. From 36% in 2010 to 84% in 2018, sub-Saharan Africa has tested more suspected cases due to the widespread use of cost-effective RDTs. The majority of malaria diagnoses from 2013 to 2019 were made with RDTs [9]. RDTs have limitations, especially in resource-limited settings and early infection. A microfluidic point-of-care (mPOC) immunoassay was developed to quantify *Plasmodium falciparum* histidine-rich protein 2 (PfHRP2) in whole blood to overcome the limitations of traditional tests, which only give binary results and lack the sensitivity to detect many asymptomatic infections. The field-deployable, simple mPOC immunoassay does not require plasma separation and provides results in 15 minutes via a smartphone app. Two diagnostic modes have been developed to detect PfHRP2 at low (100's pg/mL) and high (1.000's ng/mL) concentrations, making it useful for multiple diagnostic applications, including asymptomatic infection [10].

In light of these evolving circumstances, recent scientific reports advise malaria control caution. Climate change and drug resistance are changing malaria transmission worldwide, so we must constantly adjust our strategies. New malaria vaccines like RTS,S/AS01, and R21/Matrix-M are groundbreaking. Tafenoquine's single-dose regimen and mPOC immunoassay improve treatment and detection. Continued real-world monitoring and malaria control research will reveal their impact.

Article information and declarations

Author contributions

All authors contributed equally to the conception, writing, and revision of this letter to the editor. All authors have read and approved the final version of the manuscript.

Conflict of interest

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LETTER TO THE EDITOR

POST-COVID-19 HAEMATOLOGIC CHANGES: POTENTIAL MECHANISMS BEHIND INCREASED ANAEMIA RECOGNITION

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Dear Editor,
recently, I had the pleasure to read the publication by Acar et al. [1] in the Journal of Disaster and Emergency Medicine. The authors discuss the problem of anaemia detection rising between September 2020 and September 2023, specifically haemolytic anaemia and investigate any possible connections to the COVID-19 pandemic aftermath. The authors' conjectures appear to be in accordance with scientific findings concerning long COVID-19. Long COVID-19, also known as Post-Acute Sequelae of COVID-19 (PASC), is a condition where symptoms continue or appear after the initial phase of COVID-19 [2, 3]. The duration of these symptoms can extend for several weeks or even months following the resolution of the initial manifestations of the disease. The mentioned study period encompasses both the highest level of the pandemic's severity and its subsequent gradual decrease, making it a particularly intriguing timeframe for observing long-term COVID-19. With a prevalence rate ranging from 10% to as high as 30% among COVID-19 patients, this condition presents a substantial challenge for healthcare professionals and systems globally [4].

Existing literature has documented haematologic alterations in the erythroid system in individuals after recovering from COVID-19, including anaemia, elevated mean corpuscular volume, and reduced haemoglobin levels [5]. Nevertheless, what mechanisms could be responsible for these alterations? While long COVID-19 does not specifically refer to a distinct disease, it encompasses a range of symptoms, including a vascular immune-mediated response and inflammation [4, 6].

Among the different ways a disease can manifest, the involvement of cytokine-mediated thromboinflammation is especially important in this situation. The presence of microvascular thrombosis, heightened atherosclerosis, and overall endothelial damage are potential factors that could contribute to the heightened awareness of anaemia caused by erythrocyte damage while passing through modified blood vessels. In addition, the literature also documents alterations in the structure of red blood cells in COVID-19 patients that continue for several months after being discharged from the hospital [7, 8]. These modified red blood cells display a noticeable physical characteristic - an elevated standard deviation in their level of flexibility, size, and volume. However, the red blood cells of patients who have recovered do not completely return to the condition of those in the healthy group. Furthermore, certain red blood cells

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exhibited diminished dimensions and irregular morphology, prompting researchers to hypothesize the presence of fragmented erythrocytes [7].

In addition to the changes in the shape of erythrocytes, COVID-19-induced oxidative stress also impacts the proteins and lipids present in the cell membrane. This leads to a decrease in the stability of the membrane and an increase in glycolysis within the erythrocyte [8]. Mature erythrocytes cannot produce new proteins, so these alterations remain unchanged throughout their lifespan, which may explain the prolonged symptoms. Structural protein damage and membrane lipid changes may make COVID-19 patients more likely to break down red blood cells. The damage caused by oxidative stress may explain this susceptibility. The altered shape and size of some red blood cells may increase spleen trapping and reduce lifespan due to damaged capillary walls.

On the other hand, erythrocytes that have undergone fewer changes and have not been removed from the bloodstream by the spleen are still susceptible to damage because their cell membrane is less stable, their ability to change shape is reduced, and they are believed to be more sensitive to oxidative stress. Patients with chronic fatigue syndrome (CFS), which is another manifestation of long-term COVID-19, have also shown a decrease in red blood cell (RBC) deformability [9]. Erythrocytes obtained from patients with CFS exhibited reduced membrane fluidity, modified surface charge on the plasma membrane, and elevated levels of reactive oxygen species.

Long-term COVID-19 causes haematologic changes. However, the exact development of these changes is complex and the role of different processes and modifications is unclear. This letter covered the main pathophysiological changes that may cause haematologic abnormalities. Additionally, the article hypothesizes mechanisms related to the increased identification of haemolytic anaemia in Acar et al. [1] article.

Article information and declarations

Author contributions

The conceptualization and idea development for the study were carried out by Oskar Szymański. Magdalena Grzesiak was responsible for data preparation and conducting the literature review. The manuscript was written by Oskar Szymański.

Conflict of interest
All authors declare no conflict of interest.

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LETTER TO THE EDITOR

ADVANCED BIOMARKERS: ENHANCING NEUROLOGICAL PROGNOSIS IN OUT-OF-HOSPITAL CARDIAC ARREST

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To the Editor,

In recent years, there has been a significant focus on using biomarkers to predict neurological outcomes in patients who suffer from out-of-hospital cardiac arrest (OHCA) [1, 2]. Biomarkers can provide valuable information about the severity of brain damage and the expected neurological recovery of patients after cardiac arrest. This information can help guide medical decision-making and enhance patient outcomes.

Glial fibrillary acid protein (GFAP) is a significant biomarker that is extensively researched in this particular setting. Research has repeatedly linked increased concentrations of GFAP to unfavourable neurological outcomes in patients who have experienced OHCA. After a brain injury, astrocytes in the central nervous system secrete GFAP into the bloodstream. Research has shown that patients with unfavourable results have notably elevated levels of GFAP compared to those with favourable outcomes — GFAP biomarker had an area under the receiver operating characteristic curve (AUC) of 0.86 12 hours after admission. This means that it was very good at predicting negative neurological outcomes [3].

Neuron-specific enolase (NSE) is a significant biomarker. People commonly use NSE levels to evaluate neuronal injury. Researchers have linked higher levels of NSE in the blood to poor neurological outcomes [4]. This makes them useful markers for determining the early prognosis of people who have had an OHCA. According to a study, the AUC for predicting negative outcomes using NSE was consistently higher than 0.85 at different periods following cardiac arrest, obtaining the maximum predictive value 24 hours after the return of spontaneous circulation (ROSC) [5, 6].

S100B, a calcium-binding protein predominantly located in astrocytes, serves as an additional biomarker for forecasting neurological outcomes. Increased S100B levels are indicative of damage to astroglial cells and disruption of the blood-brain barrier. Researchers have found that testing S100B in the first 24 to 48 hours after an OHCA significantly improves its ability to predict adverse neurological outcomes. The authors observed the maximum AUC for S100B 24 hours after the ROSC, with a sensitivity of 79.0% and a specificity of 93.3% [7].

Researchers have also investigated the utilization of tau protein and neurofilament light chain (NFL) as biomarkers. Microtubules connect to the protein known as tau. An increase in its levels indicates damage to the axons and degeneration of nerve cells. The injury of neurons releases the protein NFL, a fundamental part of neurons, into both the

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cerebrospinal fluid and blood. Both tau and NFL have demonstrated the potential to predict neurological consequences. Research suggests that these markers possess substantial predictive efficacy, especially when assessed 48 to 72 hours after the arrest. For example, the levels of tau showed an AUC of 0.906 at 72 hours, indicating its strong predictive powers for prognosis [8].

It is recommended to incorporate diverse biomarkers into prediction models to improve neurological prognosis accuracy. GFAP, NSE, S100B, Tau, and NFL can all be used together to get a full picture of brain damage, including damage to neurons and astrocytes. Multiple marker techniques have demonstrated enhanced predictive accuracy for neurological outcomes in comparison to single biomarkers [9].

Furthermore, advancements in artificial intelligence and machine learning have enabled the creation of intricate predictive models that integrate clinical factors and biomarker data. These models possess the capability to examine intricate datasets in order to detect patterns and forecast events with a high degree of accuracy. An artificial neural network method was created to predict the neurological outcomes of OHCA patients after six months. This system showed enhanced predictive performance by using biomarkers such as NSE, S100B, GFAP, tau, neutrophil gelatinase-associated lipocalin (NGAL), and NFL, in addition to clinical data [9, 10].

Overall, biomarkers are essential for forecasting neurological outcomes in patients who have experienced OHCA. GFAP, NGAL, NSE, S100B, tau, and NFL are well-researched biomarkers that offer useful insights into various facets of brain injury. Utilizing machine learning techniques, the incorporation of various biomarkers into predictive models has the potential to greatly increase the accuracy of neurological prognostication and guide clinical decision-making in order to enhance patient outcomes after OHCA.

Article information and declarations

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