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Perceived disaster preparedness, knowledge, and skills among Sudanese healthcare professionals during the armed conflict: cross-sectional study, 2024

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Abstract

Background Disaster preparedness is a critical component of healthcare, especially in regions prone to crisis. Sudan has faced significant challenges, including armed conflict, the displacement of millions, and outbreaks of diseases such as COVID-19, acute watery diarrhoea, and dengue fever. This study evaluated the perceived preparedness, knowledge, and skills of Sudanese healthcare professionals (HCPs) in disaster management.

Methods A descriptive cross-sectional study was conducted among 1,505 HCPs via an online self-administered questionnaire. The classical Arabic version of the Disaster Preparedness Evaluation Tool (DPET) was utilised. The data were analysed via SPSS v28, with univariate and multivariate analyses performed to identify predictors of disaster preparedness, knowledge, and skills.

Results Participants perceived themselves as moderately prepared (mean 4.15 ± 1.1), knowledgeable (mean 4.01 ± 1.1), and skilled (mean 3.72 ± 1.3) in disaster management. Nurses reported higher knowledge scores than physicians, whereas male participants and those with prior disaster exposure presented higher levels of perceived preparedness, knowledge, and skills ($p < 0.001$). Previous experience in disaster management was a significant predictor of disaster management competency ($p < 0.001$). Despite moderate perceptions overall, gaps were identified in specific areas, such as familiarity with local emergency systems and disaster triage.

Conclusion Sudanese HCPs face notable gaps in disaster preparedness, knowledge, and skills, exacerbated by limited training and practical experience. Addressing these deficiencies through targeted education, disaster drills, and integrating disaster medicine into curricula is imperative to build a resilient healthcare workforce capable of managing crises effectively.

Clinical trial registration number Not applicable.

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Keywords Disaster management, Healthcare professionals, Disaster preparedness, Sudan, Disaster training

Introduction

Disasters, whether natural or human-made, lead to significant loss of life and property, and their impact varies by region, culture, and resources [1]. Sudan has faced repeated crises in recent decades, from political upheavals to epidemics and floods. Recently, violence between the Sudanese armed forces and the Rapid Support Forces caused the greatest internal displacement globally, with 9.05 million internally displaced people and 1.47 million fleeing as refugees [2]. Additionally, attacks on health personnel and facilities present heightened risks for epidemics of cholera, dengue, and other vector-borne diseases [3]. Among these challenges, the COVID-19 pandemic underscores the urgent need for strengthened disaster preparedness worldwide [4].

A new integrated disaster management (DM) framework has emerged to safeguard healthcare during crises [5]. The World Health Organization's Health Emergency and Disaster Risk Management (H-EDRM) Framework (2019) emphasises the vital role of health systems in DM, drawing on earlier global agreements such as the Sendai Framework for Disaster Risk Reduction 2015–2030 [6], the Paris Agreement on Climate Change [7], the International Health Regulations [8], and the Sustainable Development Goals 2015–2030 [9]. This approach highlights comprehensive resource coordination, preparedness, and the key responsibilities of primary health care (PHC) services in disaster response [10]. Because hospitals are central to delivering life-saving care after catastrophes, health providers must remain equipped to manage unforeseen crises [1].

Disaster preparedness encompasses all proactive actions taken prior to an event to ensure an organised response [11]. Given the frequency and severity of disasters, many institutions, including hospitals, have introduced preparedness and response plans [12, 13]. However, training gaps have been reported in similar contexts with low, particularly in low-income countries [14–17]. Formal disaster management education in Sudan has been limited; undergraduate medical curricula traditionally focus on clinical training rather than disaster medicine. However, recent emphasis by the Federal Ministry of Health and the National Emergency Care Agency has begun to address this gap through specialised training programs.

Despite the frequent disasters in Sudan, data on healthcare preparedness in the region remain scarce. PHCs appear integral to DM, but little research has explored their real-world preparedness. Moreover, Sudanese health professionals' knowledge, attitudes, and training for disaster response have not been thoroughly examined. Consequently, this study aims to assess Sudanese health professionals' perception of disaster medicine proficiency and identify gaps to improve readiness.

Materials and methods

Study design, settings, and participants

This study employed a descriptive cross-sectional design conducted entirely online among doctors, nurses, and medical assistants working in various healthcare facilities in Sudan (governmental, military, and teaching). The methodology aligns with the STROBE Statement [18]. Data were collected via the classical Arabic version of the Disaster Preparedness Evaluation Tool (DPET), which was previously validated [19]. A Google Forms survey link was created, allowing participants to complete the questionnaire upon providing informed consent.

A minimum sample size of 384 healthcare professionals was determined using Cochran's formula for an unknown population, assuming a 5% margin of error and a 95% confidence interval. In this formula, $n = Z^2 \cdot p \cdot (1 - p)/d^2$, where $n = 384$, $Z = 1.96$ (corresponding to a 95% confidence level), $p = 0.5$ (assumed prevalence for maximum variability), and $d = 0.05$ (margin of error).

The questionnaire was divided into three subscales. The first subscale assessed knowledge, skills, and individual preparedness (25 items; response range 1–6, from "strongly disagree" to "strongly agree"); the second subscale measured disaster response during the mitigation phase (14 items; 1–6 Likert scale); and the third focused on postdisaster recovery (6 items; 1–6 Likert scale). The reported Cronbach's alpha coefficients for preparation, knowledge, and skills were 0.95, 0.87, and 0.92, respectively. The original cut-off positions were retained [19]. Thus, mean values of 1–2.99 suggest low preparedness, 3–4.99 indicate moderate preparedness, and 5–6 denote high preparedness. Additional open-ended questions captured qualitative data. The demographic information collected included age, sex, marital status, education level, job position, years of experience, hospital type, weekly work hours, and prior disaster exposure.

Data collection process

Study participants were recruited primarily via frequently used social media platforms (Facebook, WhatsApp, and Telegram). Before completing the questionnaire, individuals were asked to provide electronic informed consent; they were then encouraged to share the survey link with professional colleagues to bolster participant numbers. The participants were required to sign in with a Google account to access the survey form, ensuring the uniqueness of the responses.

A pilot test of 20 participants confirmed the clarity and comprehensibility of the instrument before its widespread distribution. Prior to data collection, the participants were given detailed information about the study's objectives and the approximate time needed to complete the survey. They were also informed that participation was voluntary and that all the responses would remain anonymous and confidential. To maintain an optimal response rate, the collaborator team sent periodic reminders.

Data analysis

All the data were entered and analysed via SPSS (version 28). Descriptive statistics for categorical variables are presented as frequencies and percentages, whereas continuous variables are summarised using means and standard deviations. Pearson correlation and ANOVA were used for univariate analysis, and multivariate linear regression was employed to further investigate associations between independent variables and participants' knowledge, skills, and preparedness. Statistical significance was set at $p < 0.05$. The results were presented via narrative descriptions and tabular formats.

Table 1 Demographic characteristics of healthcare providers ($n = 1505$)

Character	Category	Count (%)/ Mean ± SD
Age		28.5 ± 1
Gender	Male	586 (38.9%)
	Female	919 (61.1%)
Marital Status	Single	1225 (81.4%)
	Married	280 (18.6%)
Education	Diploma	16 (1.1%)
	Bachelor	1208 (80.3%)
	Master	156 (10.4%)
	PhD	93 (6.2%)
	Other	32 (2.2%)
Position	Consultant	23 (1.5%)
	Specialist	82 (5.4%)
	Registrar	258 (17.1%)
	Medical officer	686 (45.6%)
	House officer	172 (11.4%)
	Prehouse officer	126 (8.4%)
	Nurse	142 (9.4%)
	Medical assistant	16 (1.1%)
Hospital	Governmental	814 (54.1%)
	University	127 (8.4%)
	Military	162 (10.8%)
	Private	402 (26.7%)
Experience	Less than 1 year	484 (32.2%)
	1–3 years	640 (42.5%)
	3–5 years	170 (11.3%)
	5–7 years	76 (5%)
	More than 7 years	135 (9%)
Working hours (week)		41.6 ± 21
Previous exposure to Disaster	No	1079 (71.7%)
	Yes	426 (28.3%)

Results

Demographic characteristics of healthcare providers

The study included 1,505 healthcare providers with a mean age of 28.5 years (± 1) (Table 1). The female participants accounted for 61.1% of the sample, whereas the male participants accounted for 38.9%. Most participants were single (81.4%), with only 18.6% married. Most participants held a bachelor's degree (80.3%), followed by a master's degree (10.4%), a PhD (6.2%), and a diploma (1.1%).

For professional roles, medical officers made up the largest group (45.6%), followed by registrars (17.1%), house officers (11.4%), and nurses (9.4%). Consultants and specialists represented 1.5% and 5.4% of the participants. Healthcare providers primarily worked in governmental hospitals (54.1%), with others distributed across private (26.7%), military (10.8%), and university hospitals (8.4%). Experience levels varied, with 42.5% reporting 1–3 years of experience, 32.2% having less than one year, and only 9% with more than seven years of experience. Weekly working hours averaged 41.6 h (± 21), and prior exposure to disaster situations was reported by 28.3% of the participants (Table 1).

Healthcare providers' perception of knowledge of disaster management

Table 2 summarizes healthcare providers' self-reported knowledge of disaster management. The mean knowledge score is 4.01 (SD = 1.10), suggesting moderately high self-perceived awareness and understanding. Among individual items, the highest mean (4.72 ± 1.39) appears for willingness to attend disaster preparedness classes tailored to the local community (Item 7), indicating a strong interest in targeted education. In contrast, the lowest mean (3.30 ± 1.68) is the perception that sufficient support from local officials exists during a disaster (Item 14), implying uncertainty or dissatisfaction with official support. The interquartile range shows that most participants rate their knowledge-related statements around 3 to 5 on the Likert scale.

Healthcare providers' perception of skills in disaster management

Table 3 presents participants' perceptions of their disaster management skills. The overall mean score here is 3.72 (SD = 1.30). The highest mean (4.07 ± 1.49) relates to awareness of potential vulnerabilities in the community (Item 17), suggesting a strong sense of local risk identification. Conversely, one of the lowest mean scores (3.30 ± 1.68) pertains to creating or lobbying for new guidelines and emergency plans (Item 15), indicating that

Table 2 Healthcare providers' perceptions of their knowledge of disaster management ($n = 1505$)

Item	Mean ± SD	25th	50th	75th
1. I participate in disaster drills or exercises at my workplace on a regular basis.	4.34 ± 1.65	3.00	5.00	6.00
2. I have participated in emergency plan drafting and planning for disaster situations in my community.	3.99 ± 1.67	2.00	4.00	5.00
3. I know who to contact (chain of command) in disaster situations in my community.	4.14 ± 1.64	3.00	5.00	5.00
4. I participate in continuing education classes, seminars, or conferences dealing with disaster preparedness.	3.95 ± 1.68	2.00	4.00	5.00
5. I read journal articles related to disaster preparedness.	3.88 ± 1.63	2.00	4.00	5.00
6. I am aware of classes about disaster preparedness and management offered at my workplace, university, or community.	4.07 ± 1.60	3.00	4.00	5.00
7. I would be interested in educational classes on disaster preparedness that relate specifically to my community.	4.72 ± 1.39	4.00	5.00	6.00
8. I find that the research literature on disaster preparedness and management is easily accessible.	3.90 ± 1.48	3.00	4.00	5.00
9. I find that the research literature on disaster preparedness is understandable.	4.16 ± 1.40	3.00	4.00	5.00
11. Finding relevant information about disaster preparedness is an obstacle to my level of preparedness.	4.11 ± 1.45	3.00	4.00	5.00
12. I know where to find relevant research or information to fill in gaps in my knowledge.	3.91 ± 1.50	3.00	4.00	5.00
13. I have a list of contacts in the medical/health community (e.g., referral contacts) in case of a disaster.	3.70 ± 1.67	2.00	4.00	5.00
14. I think there is sufficient support from local officials in a disaster situation.	3.30 ± 1.68	2.00	3.00	5.00
Overall disaster management knowledge	4.01 ± 1.10	—	—	—

Table 3 Healthcare providers' perceptions of their disaster management skills ($n = 1505$)

Item	Mean ± SD	25th	50th	75th
10. I consider myself prepared for the management of disasters.	3.74 ± 1.57	3.00	4.00	5.00
15. I participate/have participated in creating new guidelines, emergency plans, or lobbying for improvements on the local/national level.	3.30 ± 1.68	2.00	3.00	5.00
16. I would be considered a key leadership figure in my community in a disaster situation.	3.77 ± 1.61	3.00	4.00	5.00
17. I am aware of the potential vulnerabilities in my community (e.g., earthquakes, floods, terror).	4.07 ± 1.49	3.00	4.00	5.00
19. In case of a bioterrorism/biological attack, I know how to use personal protective equipment.	3.84 ± 1.62	3.00	4.00	5.00
20. In case of a bioterrorism/biological attack, I know how to execute decontamination procedures.	3.61 ± 1.62	2.00	4.00	5.00
21. In case of a bioterrorism/biological attack, I know how to perform isolation procedures to minimise community exposure.	3.79 ± 1.61	3.00	4.00	5.00
22. I am familiar with the local emergency response system for disasters.	3.51 ± 1.62	2.00	4.00	5.00
23. I am familiar with accepted triage principles used in disaster situations.	3.82 ± 1.62	3.00	4.00	5.00
24. I have personal/family emergency plans in place for disaster situations.	3.70 ± 1.62	2.00	4.00	5.00
25. I have an arrangement with loved ones on how to execute our personal/family emergency plans.	3.80 ± 1.66	2.00	4.00	5.00
Overall disaster management skills	3.72 ± 1.30	—	—	—

fewer participants actively engage in policy-level interventions. The percentiles reveal that most respondents rate themselves around a 3 or 4 in skill-based activities.

Healthcare providers' perception of preparedness for disaster management

Table 4 focuses on participants' self-perceived preparedness for disaster response and management. The aggregate preparedness score is 4.15 (SD = 1.10), suggesting that, on average, respondents feel relatively prepared. Several items stand out for their high means: knowing the limits of one's professional scope (Item 18, 4.52 ± 1.41) and identifying clusters of similar symptoms in mass-exposure scenarios (Item 26, 4.58 ± 1.29). However, familiarity with organizational logistics across local, state, and federal agencies (Item 37, 3.67 ± 1.58) shows a lower mean. Overall, the interquartile ranges hover between 3 and 5, reinforcing that most participants have at least moderate confidence in disaster preparedness.

Univariate analysis of knowledge, skills, and preparedness

Univariate analysis revealed several significant associations between participant characteristics and disaster management domains (Table 5):

- **Age**: Older participants had higher scores in knowledge ($r = 0.08$, $p = 0.001$), skills ($r = 0.08$, $p = 0.001$), and preparedness ($r = 0.07$, $p = 0.001$).
- **Gender**: Male participants scored significantly higher than females in knowledge (mean = 4.14 ± 1.1 vs. 3.93 ± 1.1, $p = 0.001$), skills (3.90 ± 1.3 vs. 3.60 ± 1.2, $p = 0.001$), and preparedness (4.27 ± 1.1 vs. 4.01 ± 1.1, $p = 0.001$).
- **Marital Status**: No significant differences were observed between single and married participants in any domain ($p > 0.05$).
- **Education**: Participants with higher educational levels (e.g., Master's degrees) had significantly higher scores in knowledge, skills, and preparedness ($p < 0.01$).

Table 4 Healthcare providers' perceptions of their preparedness for disaster management ($n = 1505$)

Item	Mean ± SD	25th	50th	75th
18. I know the limits of my knowledge, skills, and authority, and when I exceed them in disaster situations.	4.52 ± 1.41	4.00	5.00	6.00
26. I can identify indicators of mass exposure by clustering of patients with similar symptoms.	4.58 ± 1.29	4.00	5.00	6.00
27. I can manage common symptoms/reactions of disaster survivors (affective, behavioral, cognitive, physical).	4.29 ± 1.35	4.00	5.00	5.00
28. I am familiar with psychological interventions, behavioral therapy, support groups, and debriefing for those who experience trauma.	4.11 ± 1.45	3.00	4.00	5.00
29. I can describe my role in the response phase of a disaster (workplace, public, media, personal contacts).	4.25 ± 1.42	3.00	5.00	5.00
30. I am familiar with the main groups (A, B, C) of biological weapons (e.g., anthrax, plague, botulism) and their signs, symptoms, and effective treatments.	3.75 ± 1.57	3.00	4.00	5.00
31. I feel confident discerning deviations in health assessments indicating potential exposure to biological agents.	3.83 ± 1.51	3.00	4.00	5.00
32. I feel confident in my abilities as a direct care provider and first responder in disaster situations.	4.35 ± 1.44	4.00	5.00	5.00
33. I would feel confident as a manager or coordinator of a shelter.	4.16 ± 1.50	3.00	4.00	5.00
34. I would feel reasonably confident as a member of a decontamination team.	4.41 ± 1.42	4.00	5.00	6.00
35. In case of a bioterrorism/biological attack, I know how to perform a focused health history and assessment for the relevant bioagents.	4.12 ± 1.47	3.00	4.00	5.00
36. I feel reasonably confident treating patients independently without supervision in a disaster situation.	4.20 ± 1.48	3.00	5.00	5.00
37. I am familiar with the logistics and roles among local, state, and federal agencies in disaster response.	3.67 ± 1.58	2.00	4.00	5.00
38. I feel confident implementing emergency plans, evacuation procedures, and similar functions.	4.12 ± 1.50	3.00	4.00	5.00
39. I feel confident providing patient education on stress and abnormal functioning related to trauma.	4.45 ± 1.46	4.00	5.00	6.00
40. I feel confident providing education on coping skills and training for patients who experience traumatic situations.	4.19 ± 1.48	3.00	4.00	5.00
41. I can discern signs and symptoms of Acute Stress Disorder and Post Traumatic Stress Syndrome (PTSD).	4.34 ± 1.39	4.00	5.00	5.00
42. I am familiar with the scope of my role as a doctor/nurse practitioner in a postdisaster situation.	4.29 ± 1.43	3.00	5.00	5.00
43. I participate in peer evaluation of skills on disaster preparedness and response.	3.80 ± 1.55	3.00	4.00	5.00
44. I am familiar with how to perform a focused health assessment for PTSD.	3.87 ± 1.50	3.00	4.00	5.00
45. I feel confident managing emotional outcomes (e.g., ASD, PTSD) in a multidisciplinary way (referrals, follow-ups) postdisaster.	3.89 ± 1.53	3.00	4.00	5.00
Overall disaster preparedness	4.15 ± 1.10	—	—	—

- **Position**: Nurses and consultants had the highest scores in knowledge (4.40 ± 1.0 and 4.33 ± 1.2, respectively), skills (4.32 ± 1.1 and 4.13 ± 1.4), and preparedness (4.61 ± 0.9 and 4.43 ± 1.2), while house officers and medical assistants scored lowest across all domains ($p < 0.001$).
- **Hospital Sector**: No significant differences in scores were found between governmental, university, military, or private hospitals ($p > 0.05$).
- **Experience**: Participants with more than 7 years of experience had the highest scores in knowledge (4.37 ± 1.2), skills (4.10 ± 1.3), and preparedness (4.47 ± 1.2), with significant differences across experience levels ($p < 0.001$).
- **Working Hours**: Increased weekly working hours were positively associated with higher scores in knowledge ($r = 0.11$, $p < 0.001$), skills ($r = 0.11$, $p < 0.001$), and preparedness ($r = 0.12$, $p < 0.001$).
- **Previous Disaster Exposure**: Participants with prior disaster exposure scored significantly higher than those without in knowledge (4.39 ± 1.0 vs. 3.86 ± 1.1), skills (4.18 ± 1.1 vs. 3.54 ± 1.3), and preparedness (4.57 ± 0.9 vs. 3.99 ± 1.1) ($p < 0.001$).

Multivariate analysis of knowledge, skills, and preparedness

Multivariate linear regression identified several predictors of disaster knowledge, skills, and preparedness (Table 6):

- **Previous Disaster Exposure** was the strongest predictor across all three domains:
- It was positively associated with knowledge ($\beta = 0.180$, $p < 0.001$), skills ($\beta = 0.185$, $p < 0.001$), and preparedness ($\beta = 0.196$, $p < 0.001$), indicating that participants with prior exposure to disasters had significantly higher scores in all areas after adjusting for other variables.
- **Experience** was also a significant positive predictor of knowledge ($\beta = 0.144$, $p < 0.001$), skills ($\beta = 0.172$, $p < 0.001$), and preparedness ($\beta = 0.199$, $p < 0.001$), suggesting that healthcare workers with more years of experience reported greater competence in disaster management.
- **Position** was significantly associated with higher scores in knowledge ($\beta = 0.085$, $p = 0.004$), skills ($\beta = 0.114$, $p < 0.001$), and preparedness ($\beta = 0.093$, $p = 0.002$).

Table 5 Univariate analysis of knowledge, skills, and preparedness by demographic characteristics ($n = 1505$)

Character	Category	Knowledge		Skills		Preparedness	
		Mean± SD	*p* value	Mean± SD	*p* value	Mean± SD	*p* value
Age		0.08	**0.001**	0.08	0.001	0.07	**0.001**
Gender	Male	4.14 ± 1.1	**0.001**	3.90 ± 1.3	0.001	4.27 ± 1.1	**0.001**
	Female	3.93 ± 1.1		3.60 ± 1.2		4.01 ± 1.1	
Marital Status	Single	3.99 ± 1.1	0.256	3.72 ± 1.3	0.972	4.15 ± 1.1	0.797
	Married	4.08 ± 1.1		3.72 ± 1.3		4.13 ± 1.1	
Education	Diploma	3.97 ± 1.1	**0.001**	3.80 ± 1.2	**0.001**	4.11 ± 1.3	**0.002**
	Bachelor	3.98 ± 1.1		3.68 ± 1.3		4.13 ± 1.1	
	Master	4.33 ± 1.1		4.07 ± 1.3		4.39 ± 1	
	PhD	4.01 ± 1.2		3.75 ± 1.3		4.18 ± 1.1	
	Other	3.38 ± 1.4		3.12 ± 1.4		3.56 ± 1.2	
Position	Consultant	4.33 ± 1.2	**< 0.001**	4.13 ± 1.4	< 0.001	4.43 ± 1.2	**< 0.001**
	Specialist	4.10 ± 1.2		3.86 ± 1.4		4.29 ± 1.1	
	Registrar	4.14 ± 1.2		3.86 ± 1.3		4.28 ± 1.1	
	Medical officer	3.94 ± 1		3.64 ± 1.2		4.08 ± 1	
	House officer	3.80 ± 1.2		3.32 ± 1.4		3.90 ± 1.2	
	Pre-H O	3.90 ± 1.2		3.63 ± 1.3		4.01 ± 1.2	
	Nurse	4.40 ± 1		4.32 ± 1.1		4.61 ± 0.9	
	M. Assistant	3.80 ± 1.1		3.39 ± 1.3		3.75 ± 1.5	
Hospital	Governmental	4.01 ± 1.1	0.402	3.70 ± 1.3	0.532	4.16 ± 1.1	0.837
	University	3.92 ± 1.1		3.63 ± 1.3		4.12 ± 1	
	Military	3.94 ± 1.1		3.72 ± 1.3		4.22 ± 1	
	Private	4.08 ± 1.1		3.80 ± 1.3		4.13 ± 1.2	
Experience	< 1 year	3.72 ± 1.2	**< 0.001**	3.33 ± 1.3	< 0.001	3.82 ± 1.2	**< 0.001**
	1–3 years	4.12 ± 1		3.87 ± 1.2		4.26 ± 1	
	3–5 years	4.11 ± 1.1		3.82 ± 1.2		4.32 ± 1	
	5–7 years	4.15 ± 1.2		4.02 ± 1.2		4.43 ± 0.9	
	> 7 years	4.37 ± 1.2		4.10 ± 1.3		4.47 ± 1.2	
Working hrs/week		0.11	**< 0.001**	0.11	**< 0.001**	0.12	**< 0.001**
Previous exposure to disaster	No	3.86 ± 1.1	**< 0.001**	3.54 ± 1.3	**< 0.001**	3.99 ± 1.1	**< 0.001**
	Yes	4.39 ± 1		4.18 ± 1.1		4.57 ± 0.9	

Table 6 Multivariate analysis of predictors of knowledge, skills, and preparedness ($n = 1505$)

Character	Knowledge		Skills		Preparedness	
	Beta	*p* value	Beta	*p* value	Beta	*p* value
Age	-0.018	0.661	-0.017	0.662	-0.044	0.273
Gender	-0.042	0.113	**-0.056**	**0.033**	-0.002	0.397
Marital Status	0.021	0.493	-0.002	0.940	-0.015	0.619
Education	-0.039	0.165	-0.031	0.270	-0.048	0.09
Position	**0.085**	**0.004**	**0.114**	**< 0.001**	**0.093**	**0.002**
Experience	**0.144**	**< 0.001**	**0.172**	**< 0.001**	**0.199**	**< 0.001**
Working hrs/week	**0.063**	**0.016**	**0.065**	**0.013**	**0.066**	**0.012**
Previous exposure to disaster	**0.180**	**< 0.001**	**0.185**	**< 0.001**	**0.196**	**< 0.001**

- **Working Hours per Week** showed a positive association with all three domains: knowledge ($\beta = 0.063$, $p = 0.016$), skills ($\beta = 0.065$, $p = 0.013$), and preparedness ($\beta = 0.066$, $p = 0.012$), indicating that greater involvement in clinical work enhances disaster-related competencies.

Healthcare providers' perception of educational needs for disaster management

The most commonly reported educational need was understanding the scope of their role and practice in disaster situations (37.8%) (Table 7). Other notable needs included identifying community vulnerabilities (19.1%), understanding biological agents and their differential diagnosis and treatment (17.8%), and knowing available resources such as emergency contacts, community

Table 7 Educational needs for disaster management among healthcare providers ($n = 1505$)

	Count (%)
My role (my scope of practice, skills) as a doctor/nurse practitioner in a disaster situation.	569 (37.8%)
What potential vulnerabilities exist in my community in case of a disaster	288 (19.1%)
How to respond and assure health promotion, protection, and disease prevention in the community settings such as clinics or doctors' offices in case of disaster	287 (19.1%)
Biological agents and ways to identify their signs and symptoms	268 (17.8%)
Biological agents and their differential diagnosis and treatments	268 (17.8%)
Resources in my community such as agencies for referral, health departments, emergency contacts, the chain of command, and community shelters	284 (18.9%)
Recovery state: acute stress disorder, posttraumatic stress disorder, and crisis intervention (focused assessment, debriefing strategies, and behavioral, cognitive, or medication therapy)	285 (18.9%)
I feel prepared for disaster	794 (52.8%)

shelters, and health department services (18.9%). Educational needs related to recovery phases, such as managing acute stress disorder and posttraumatic stress disorder (PTSD), were also highlighted (18.9%). Despite these gaps, more than half of the participants (52.8%) reported feeling prepared for disasters (Table 7).

Discussion

Key findings of the study

This cross-sectional survey examined the perceived levels of disaster preparedness, knowledge, and skills among 1,505 Sudanese healthcare professionals (HCPs) in the midst of an armed conflict. The overall results revealed moderate preparedness (mean = 4.15), moderate knowledge (mean = 4.01), and slightly lower skills (mean = 3.72). Nurses and consultants scored consistently higher across these domains, while younger providers, such as house officers, reported lower confidence and knowledge. Prior exposure to disaster events emerged as the strongest predictor of high perceived competence in all areas. Nevertheless, critical gaps were identified, including a limited grasp of local emergency systems, insufficient collaboration in disaster planning, and inadequate familiarity with triage protocols.

Comparison with similar African, Arab, and international contexts

These results mirror moderate to low disaster readiness across many African and Middle Eastern settings. In Ethiopia, studies frequently cite poor knowledge, limited participation in drills, and minimal structured training [11, 14–16]. Similar trends emerge in Namibia [17], Saudi Arabia [1, 20, 21], the UAE [4], Qatar [22], Jordan [23], and Yemen [24], where moderate awareness coexists with few formal programs. International research in China [25], Indonesia [26], and the United States [27–29] further underscores that theoretical familiarity alone is inadequate without practical preparedness—an issue paralleled in our Sudanese sample.

Factors affecting variations in disaster preparedness

Several factors consistently shape the variation in disaster readiness. In this study, prior disaster exposure emerged as the single strongest predictor of higher knowledge, skills, and preparedness scores, which was also observed by Tassew et al. [11], Nofal et al. [1], and Berhanu et al. [15]. Professional role and years of experience further delineated competence levels: nurses and consultants in our sample scored better than peers, mirroring Al Thobaity et al. [20], who reported superior disaster preparedness among military nurses in Saudi Arabia. Lack of systematic training, however, persists as a major barrier across both low- and middle-income countries (LMICs) and wealthier regions.

Male participants perceived themselves as more knowledgeable, skilled, and prepared for disasters than females, consistent with previous studies' findings [23, 28]. This gender difference may reflect disparities in training opportunities or workplace roles. Although our data did not reveal significant differences by hospital sector, other studies highlight possible variations, for instance, between military and civilian hospitals, attributable to differing resource allocations or institutional priorities [20].

Recommendations

Based on these findings, disaster management should be integrated into medical and nursing curricula to equip healthcare professionals with practical skills such as triage, mass casualty management, and recovery strategies. While some training exists, mainly through the emergency care agency funded by some NGOs, it remains limited in accessibility, particularly across the rural and private sectors.

Mandatory disaster drills and role-specific training for doctors, nurses, and medical assistants should be implemented to enhance hands-on preparedness. Training programs must also ensure gender equity by addressing barriers female healthcare workers face.

Community-centred programs should focus on local vulnerabilities and available resources, such as referral

systems and emergency shelters. To ensure uniform delivery across public, private, and military sectors, a national training framework should be established under the Federal Ministry of Health in collaboration with the National Council for Civil Defence. Funding could come from government budgets, international donors, and public-private partnerships.

Improving access to updated disaster protocols and promoting ongoing education, interdisciplinary collaboration, and workshops are essential to building a resilient healthcare system. Future research should include diverse healthcare settings and adopt mixed-method approaches to explore gaps and solutions in disaster preparedness.

Limitations

This study has several limitations. Data collection was conducted online due to the ongoing conflict in Sudan, which potentially introduced selection bias. The study relied solely on quantitative data, which limits the ability to capture the depth and complexity of participants' perceptions. Future research should involve more representative samples across all Sudanese states and employ mixed-methods approaches to provide richer insights into disaster preparedness and training needs.

Conclusion

This study highlights critical knowledge, skills, and preparedness gaps among Sudanese healthcare professionals for disaster management. Given the profound impact of disasters, these deficiencies must be urgently addressed. First responders, in particular, need to be equipped to handle emergencies effectively. Specific areas of disaster medicine, such as triage, evacuation, and first aid, should be prioritised. Integrating disaster medicine into the education and continuous professional development of medical and nursing staff is essential for building a resilient healthcare workforce capable of responding to future crises.

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Author contributions

Fatima A. Ayyad and Roa Abdalsalam contributed to the conceptualisation, methodology, investigation, validation, writing of the initial draft, and revision of the final draft. Eltayeb Abdalla handled data curation, formal analysis, interpretation, and final draft revision. Salih B. Hamza was involved in the methodology, investigation, writing of the initial draft, and final draft revision. Baha Aldeen Alshareif contributed to the revision of the final draft. The following authors contributed to the data collection and final draft revision: Alaa A. Ayyad, Alaa Salih, Rana Hassan, Noura Mamdouh, Elmustafa Emad, Mihad Adil, Mohamed Abdelgader, Hussamaldin Mohammed, Maha Adam, Almiqdad Salahaldin, Faisal Shiekh, Afrah Tageldin, Walaa Mamoun, and Anfal Alamir. Mohi Eldin Hassan provided supervision, contributed to methodology and validation, and was involved in writing the initial draft and revising the final draft.

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Data availability

The data set analysed in this study is available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Research and Training Ethical Committee at the Federal Ministry of Health, Sudan. The study was conducted in compliance with the Helsinki Declaration (https://www.wma.net/policies-post/wma-declaration-of-helsinki/).

Consent for publication

Not applicable; the study does not contain any identifying images or other personal or clinical details of participants.

Informed consent

was electronically signed by each participant before their participation.

Competing interests

The authors declare no competing interests.

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