



WRJBHS-25-102

Effectiveness and Challenges of Public Health Surveillance and Disease Outbreaks Control in War Zones: A Case Study in South Darfur, 2023

Magam Kassar^{1*}, Omer Albadri^{1,2}

¹Federal Ministry of Health, Directorate of Health Emergencies and Epidemics Control (HEEC), Khartoum, Sudan

²Field Epidemiology Training Program, Sudan

*Correspondence: Magam Kassar, Federal Ministry of Health, Directorate of Health Emergencies and Epidemics Control (HEEC), Khartoum, Sudan, E-mail: Magammohamed@gmail.com; DOI: <https://doi.org/10.56147/jbhs.2.6.102>

Citation: Kassar M, Albadri O (2025) Effectiveness and Challenges of Public Health Surveillance and Disease Outbreaks Control in War Zones: A Case Study in South Darfur, 2023. J Biol & Heal Sci 2: 102.

Abstract

Public health surveillance in South Darfur relies on a combination of governmental and non-governmental efforts. However, the effectiveness of these systems is hampered by the lack of stable communication networks, inadequate data collection methods and the intermittent presence of health workers due to security concerns. Many health facilities have been damaged or destroyed and remain operational often lack essential medical supplies and adequately trained staff. This deterioration has undermined the region's ability to effectively monitor and respond to public health issues. This Study examines the specific challenges facing South Darfur state, Sudan, where effective disease outbreak response and Surveillance disrupted in late May 2023. The study followed the FMOH guidelines and tools. Structured discussions, observation and review of records and guidelines were done at state and localities levels. Quantitative data collected through a questionnaire of health care providers and community members in South Darfur, focusing on access to health care, disease prevalence and perceptions of surveillance effectiveness. Qualitative data collected through interviews with key stakeholders, including healthcare workers, humanitarian organizations and government officials, to provide nuanced insights into the challenges and strategies for managing disease outbreaks in war zones. Two hundred from Community volunteers and health workers from different levels were interviewed through google form. Director of Health Emergency and Epidemic Control, surveillance officers and focal persons for surveillance at the locality level were also interviewed. SPSS software was used to perform descriptive statistical analysis for quantitative data, while qualitative data was analyzed manually using thematic analysis, paying particular attention to the public health surveillance system level allowing for an exploration of effectiveness and challenges differ across levels to provide nuanced insights into the challenges and strategies for managing disease outbreaks in war zones. Written and verbal consents were obtained from all participants as appropriate.

Keywords: Public health; Diseases; War zones; South Darfur; Healthcare; Surveillance system; Epidemic control; Community volunteers

Received date: December 08, 2025; **Accepted date:** December 15, 2025; **Published date:** December 29, 2025

Introduction

Global public health surveillance is defined as the ongoing, systematic collection, analysis and interpretation of health-related data essential to the planning,

implementation and evaluation of public health practice. This process is closely integrated with the timely dissemination of these data to those responsible for prevention and control measures [1,2].

The conflict in the Darfur region of Sudan was not new,



but this was the first time that it had arisen within the capital of South Darfur state and led to the destruction of infrastructure and institutions and created widespread insecurity and instability and profound humanitarian challenges [3,4]. Amid this unrest, public health is facing severe pressure under extreme strain, worsening already poor health outcomes for the population. Disruption of healthcare infrastructure and services has severely hampered disease surveillance and outbreak management efforts, increasing community vulnerability to a range of health threats [5].

In this context, South Darfur State emerges as a focal point for understanding the complexities of conducting public health surveillance and managing disease outbreaks during conflict. Located in western Sudan, South Darfur has suffered repeated violence and instability, impacting its population profoundly [6]. Maintaining effective surveillance systems and promoting epidemic awareness in war zones presents enormous challenges that urgently need to be addressed [7].

In response to these challenges, health authorities and humanitarian actors have implemented surveillance strategies, including Community-Based Surveillance (CBS) and early warning alert systems, to mitigate the spread of diseases [8].

This paper highlights lessons learned, identifies gaps in current strategies and proposes practical recommendations to strengthen surveillance and response systems in South Darfur, focusing on real-time experiences from South Darfur during ongoing conflict and impact on health systems.

Methodology

Study design

This cross-sectional study was conducted in South Darfur, Sudan, a region heavily impacted by armed conflict since April 2023. A mixed-methods approach was adopted, integrating quantitative and qualitative techniques to assess the performance of public health surveillance and epidemic response systems under crisis conditions.

Study population

The target population included healthcare providers, community members, humanitarian workers and public health and surveillance officer operating in conflict-affected areas

Data collection methods

Questionnaire survey

A semi-structured questionnaire (in Arabic and English) with 20 close-ended and several open-ended items was distributed *via* Google Forms and WhatsApp. It

assessed demographics, surveillance awareness, access to services, knowledge of epidemics and improvement recommendations. Phone interviews were conducted to include respondents in remote or insecure areas.

In-depth interviews

Semi-structured interviews were conducted with healthcare personnel and public health authorities to explore surveillance system challenges, strengths and practical recommendations under conflict conditions.

All instruments were pre-tested for clarity and relevance. Ethical standards, including informed consent and confidentiality, were strictly maintained.

Data analysis

Quantitative data were analyzed using SPSS (descriptive statistics, frequencies and cross-tabulations). Qualitative data were coded and thematically analyzed to identify barriers, adaptive strategies and personal experiences. This triangulated approach enhanced the reliability and contextual richness of findings.

Result

Impact of war on public health surveillance awareness and epidemic management in South Darfur.

Participants

A total of 200 individuals from various demographic groups in South Darfur participated in this study.

Age range: 15-65 years.

Data collection

Data was gathered using a structured questionnaire aimed at assessing participants' awareness of health surveillance and epidemic management systems during the ongoing war.

Data analysis

A quantitative analysis was conducted to evaluate the responses and determine the general level of awareness among the participants regarding health monitoring and epidemic response systems.

Results

Demographic profile of respondents

Age distribution: Most respondents (30%) were between 15-25 years, followed by 26-35 years (25%) and 36-45 years (20%).

Gender: Males constituted 55% of respondents; females 45%.



Education: A significant proportion (45%) had higher education, while 15% had no formal education.

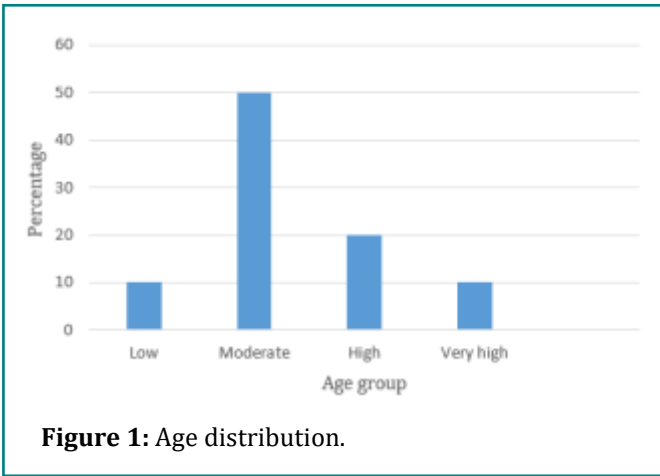


Figure 1: Age distribution.

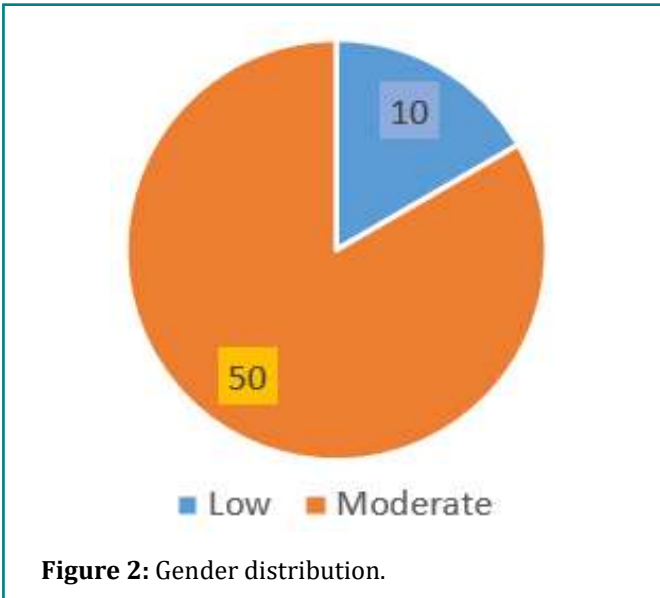


Figure 2: Gender distribution.

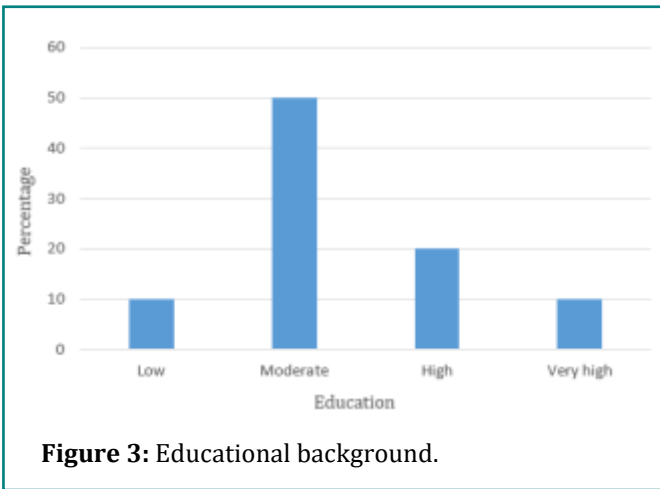


Figure 3: Educational background.

This demographic profile provides insights into the awareness and understanding levels across age and education gradients, important for interpreting perceptions of surveillance and epidemic response.

Awareness and understanding of surveillance systems

Figures 4, 5 and 6 highlight knowledge gaps and limited awareness of public health surveillance mechanisms:

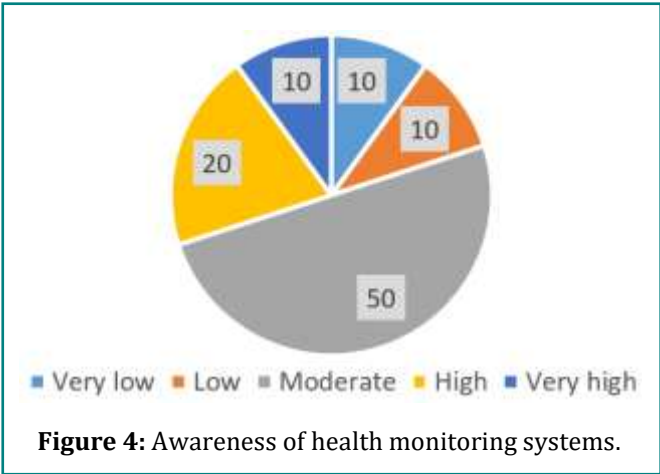


Figure 4: Awareness of health monitoring systems.

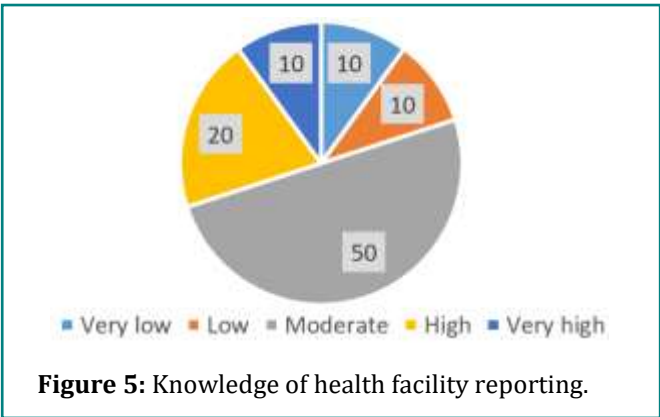


Figure 5: Knowledge of health facility reporting.

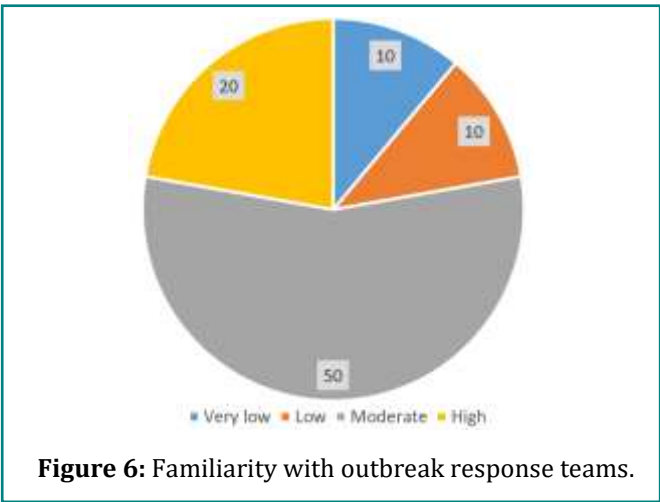


Figure 6: Familiarity with outbreak response teams.

Awareness of health monitoring systems: Only 25% rated their awareness as moderate or higher, with 50% describing it as weak or very weak.

Knowledge of health facility reporting: 40% reported their knowledge as good or excellent, while 35%

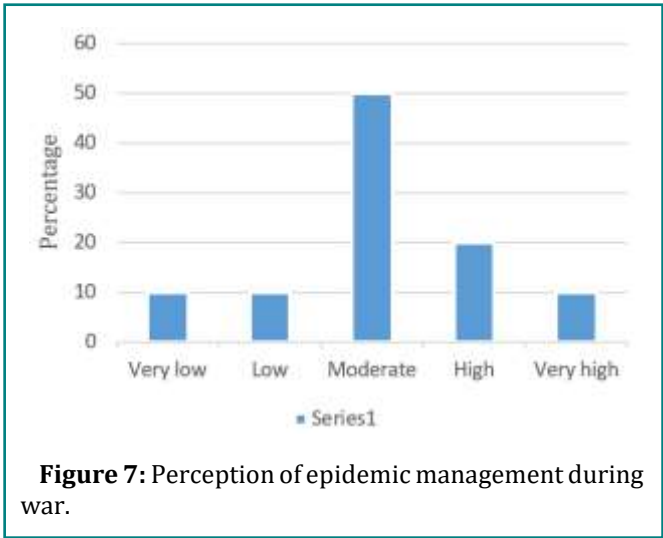


had poor or very weak understanding.

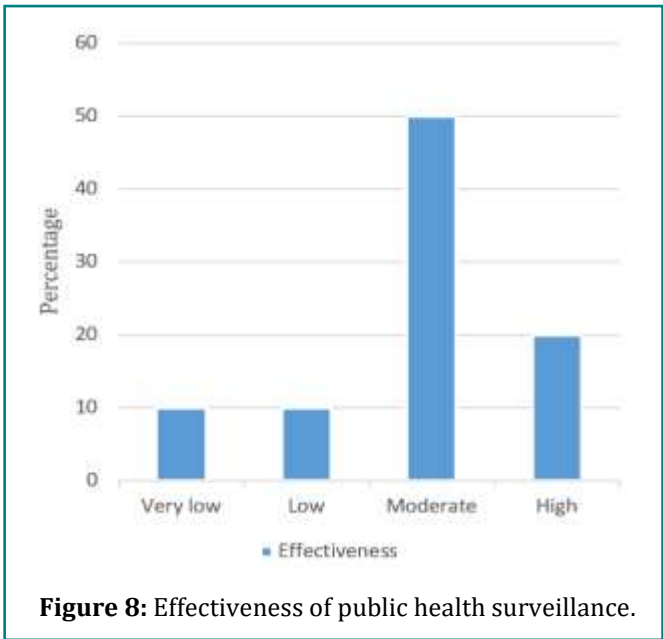
Familiarity with outbreak response teams: Nearly half (45%) were not familiar at all, showing a significant communication and training gap.

Perceptions of epidemic management during conflict

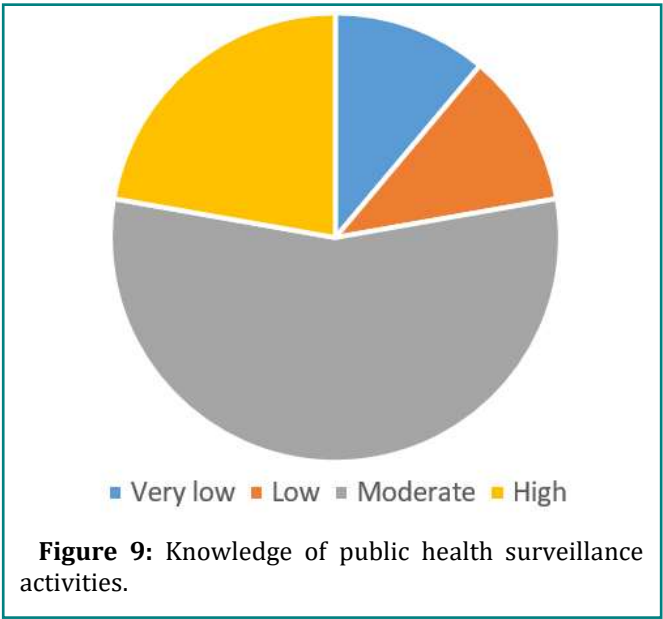
Perception of Management: 70% rated epidemic management as very low or low during the war (**Figure 7**).



Effectiveness of public health surveillance: 67% considered the system inactive, while only 8% described it as very effective (**Figure 8**).



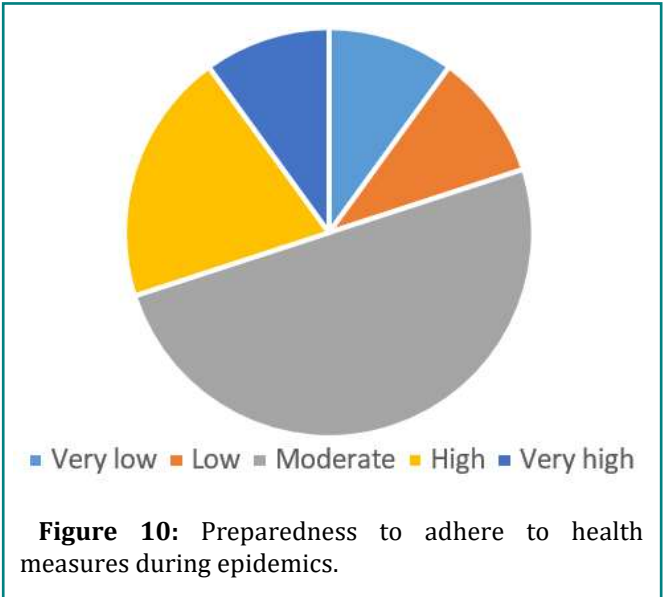
Knowledge of surveillance activities: 60% had very low or low awareness, reinforcing the perception of disconnect between the system and the community (**Figure 9**).



Community preparedness and health behaviors

Despite weaknesses in surveillance, respondents showed some readiness to adhere to health measures (**Figure 10**):

- 50% rated their preparedness as high or very high.
- This shows potential for better engagement if health systems are strength and outreach is improved.



Understanding of epidemics and information channels

Understanding during war: 50% had a moderate understanding, but 20% remained at a low level (**Figure 11**).

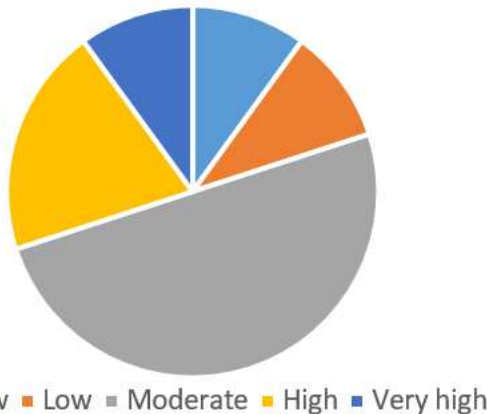


Figure 11: Understanding epidemics during war and sources of information.

This suggests that targeted risk communication can build on existing awareness but needs to be expanded.

Key informant interviews

The key challenges that undermined the effectiveness of public health surveillance and disease outbreak control efforts in South Darfur during the 2023 conflict. Insights are drawn from interviews with health officials, frontline workers and humanitarian partners.

Severely limited surveillance capacity: The effectiveness of disease surveillance systems was significantly reduced due to the breakdown of communication infrastructure, widespread insecurity, financial shortages and the absence of logistical support. According to the Director of Health Emergencies, these conditions led to delays in detecting dengue fever outbreaks, allowing the disease to spread beyond South Darfur reaching North Darfur before formal detection occurred.

Resource scarcity and health system weaknesses: Health professionals consistently reported a critical shortage of essential medical supplies, health personnel, diagnostic tools and communication equipment. These constraints compromised not only outbreak detection but also the sustainability of the broader epidemic preparedness and response system in the region.

Insecurity and restricted access: Ongoing armed conflict and unstable security conditions severely restricted the mobility of health teams. Many affected areas became inaccessible, obstructing field visits, data collection and contact tracing efforts. As a result, timely outbreak verification and response were nearly impossible in several locations.

Fragmented coordination mechanisms: Respondents emphasized that coordination among government entities, humanitarian actors and implementing agencies was weak or absent. Poor

information sharing, unclear mandates and the absence of unified leadership during the crisis led to fragmented and inefficient responses to health emergencies.

Funding disruptions and partner withdrawal: The conflict led to the suspension or withdrawal of funding from key international partners, resulting in significant gaps in health service delivery and surveillance operations. Health authorities were left with insufficient resources to maintain core functions of surveillance systems such as EWARN and IDSR.

Displacement and population movement: Mass displacement of civilians from conflict zones, combined with the collapse of infrastructure, played a key role in accelerating the spread of vector-borne diseases like dengue fever. Overcrowded IDP settlements with poor sanitation created environments conducive to disease transmission, further overwhelming the weakened health system.

Disruption of routine immunization services: Routine immunization services were severely disrupted during the conflict in South Darfur. Health facilities that typically delivered essential vaccines such as measles, polio and DTP were either damaged, inaccessible or operating at minimal capacity due to insecurity, displacement of health workers and supply chain interruptions. Outreach services were suspended in many areas, especially those classified as high-risk or under armed control. As a result, significant immunity gaps emerged, increasing the risk of vaccine-preventable disease outbreaks, particularly among children in Internally Displaced Persons (IDP) camps. Several respondents noted missed vaccination campaigns and stockouts of critical antigens, further undermining the effectiveness of disease prevention efforts during the crisis.

Operational surveillance gaps: Although surveillance systems formally remained in place, their functional effectiveness was compromised. Health staff noted that reporting tools, trained personnel and reliable communication were lacking, rendering the surveillance system unable to detect and respond to outbreaks in real time.

Discussion

This study highlights the profound challenges and limited effectiveness of public health surveillance and disease outbreak control in South Darfur during the 2023 conflict. The findings reflect a broader pattern observed in many war-affected regions, where fragile health systems collapse under the combined pressure of insecurity, displacement and resource depletion [9,10].

Quantitative data revealed that 67% of respondents perceived the surveillance system as inactive and only 8% believed it was very effective. This aligns with key



informant testimonies describing the system as technically present but functionally paralyzed, with health workers unable to report outbreaks in real time due to destroyed communication networks and lack of transportation. Such challenges are consistent with prior conflict settings where communication and mobility constraints severely limit real-time disease reporting [11,12].

The delayed detection of dengue fever, which spread from South to North Darfur undetected, exemplifies how systemic breakdowns can allow preventable diseases to escalate into regional threats an issue reported during outbreaks in Yemen and Syria [10,13].

The shortage of health workers, medical supplies and diagnostic tools as confirmed by over 60% of survey participants and multiple health officials undermined both detection and response capacity. Insecurity and population displacement further complicated service delivery, especially in rural or high-conflict zones, where mobile teams could not safely operate [9,14].

Disrupted immunization campaigns added to these risks. With many children in Internally Displaced Persons (IDP) camps missing essential vaccines like measles and polio, the area faces the possibility of secondary epidemics of vaccine-preventable diseases a common pattern in humanitarian crises [12,15].

The public's limited awareness and familiarity with outbreak response teams 45% were not familiar at all suggests a serious disconnect between surveillance systems and the communities they are meant to serve. Despite this, 50% of respondents expressed high or very high willingness to adhere to epidemic control measures, revealing a significant opportunity for community engagement if trust and communication are improved [15,16].

Poor coordination between the Ministry of Health, international agencies and NGOs led to fragmented and delayed responses. Interviewees cited confusion over roles, lack of leadership and weak data-sharing as key issues. This is consistent with global literature showing that weak inter-agency coordination in emergencies significantly reduces response efficiency and leads to duplication or neglect in service coverage [11,17].

Perhaps most concerning is the withdrawal of funding and partner support due to security risks and economic instability. These disruptions decimated surveillance efforts, forcing local systems to operate without the minimum resources required. In such settings, even robust technical tools like EWARN or IDSR become ineffective when not supported with human and financial capital [10,12].

Risk communication and public awareness campaigns are essential, not only to improve health literacy but also to empower communities to become active agents in

surveillance and outbreak control [15,16].

Results

During wartime, new strategies have been adapted because of the lack of internet. The blocking of the internet influences the quality and the quantity of health surveillance in South Darfur. The coordination between health workers, officials and local players is deeply affected.

The results of the study highlighted the demographic distribution of respondents, revealing significant differences between age groups. The age distribution of respondents was as follows:

- 15-25 years: 30%
- 26-35 years: 25%
- 36-45 years: 20%
- 46-55 years: 15%.

The gender distribution also showed a predominance of male respondents, accounting for 55%, while female respondents made up 45%.

Educational backgrounds varied, with 45% of respondents reporting higher education, 20% secondary education, 20% primary education and 15% without formal education. These demographics are crucial for understanding the population's readiness to engage in public health measures [18].

Awareness and perceptions of public health surveillance were mixed. Although a significant proportion of respondents expressed moderate to high understanding of disease reporting procedures, confidence in the government's ability to manage epidemics during wartime was very low, with 60% indicating little to no trust [7].

Effectiveness of surveillance activities was perceived as low: 67% of respondents viewed them as inactive. This perception underscores major gaps in community trust and system transparency, critical components for successful public health interventions [19].

Conclusion

The study confirms that public health surveillance and epidemic control systems in South Darfur were largely ineffective during the 2023 conflict, due to systemic, logistical and structural challenges. Quantitative data revealed limited awareness and trust in health systems, while qualitative insights exposed deep weaknesses in coordination, funding and accessibility.

These findings underline the urgent need to strengthen conflict-sensitive surveillance mechanisms, rebuild infrastructure, invest in training and re-establish community-based health networks to ensure future



preparedness in fragile settings.

Recommendations

To improve the effectiveness of public health surveillance and disease outbreak control in conflict settings such as South Darfur, several strategic actions are recommended. First, there is a critical need to strengthen Community-Based Surveillance (CBS) systems. This can be achieved by training and supporting community health workers and volunteers to serve as frontline reporters using simplified and low-tech tools, such as paper forms or SMS-based alerts. Involving local leaders and IDP camp committees in surveillance efforts would also help build trust and ensure broader coverage.

Improved coordination and information sharing among government bodies, humanitarian agencies and local stakeholders are essential. Establishing a centralized crisis coordination unit and developing a shared platform for real-time data exchange can greatly enhance collective response efforts. Clear definition of roles and joint operating procedures during emergencies will help overcome the fragmented response observed during the 2023 crisis.

Restoring and maintaining routine health services, particularly immunization, must be prioritized. Mobile vaccination campaigns should target underserved and displaced populations, while cold chain and antigen supplies need to be pre-positioned in accessible locations. At the same time, measures should be taken to ensure safe and secure access for health workers, including logistical support and coordination with local security actors.

Strengthening the surveillance infrastructure is equally important. This includes rehabilitating damaged health facilities, reactivating sentinel sites and investing in durable communication technologies such as solar-powered devices and satellite phones. Reintroducing systems like EWARN and IDSR, accompanied by updated training, will enhance outbreak detection and response readiness.

The study also highlights the need for flexible and timely funding mechanisms. Advocacy for donor flexibility, along with the establishment of national or partner-driven contingency funds, will enable rapid mobilization of resources during emergencies. In tandem, capacity building through continuous training, mentorship and remote learning opportunities should be expanded, particularly in outbreak detection, Infection Prevention and Control (IPC) and emergency response.

Importantly, surveillance activities must be integrated with Risk Communication and Community Engagement (RCCE). Health messages should be adapted to local languages and contexts and delivered through accessible channels such as radio or trusted community figures.

Transparent information sharing and the establishment of community feedback mechanisms will foster trust and encourage public participation in epidemic control measures.

Finally, regular monitoring and evaluation of the surveillance system's performance measuring factors like timeliness, completeness and response effectiveness will be essential for ensuring accountability and continuous improvement. Independent assessments during and after emergencies should be institutionalized to capture lessons learned and refine strategies for future outbreaks.

References

1. Centers for Disease Control and Prevention (2025) Introduction to public health surveillance.
2. World Health Organization (2025) Public health surveillance. WHO Regional Office for the Eastern Mediterranean.
3. International Crisis Group (2023) Sudan's conflict: Stalemate and suffering.
4. Devi S (2023) Sudan facing humanitarian crisis of epic proportions. *Lancet* 402: 1738-1739. [Crossref] [Google Scholar] [Indexed]
5. Médecins Sans Frontières (2023) Sudan: Escalating conflict deepens humanitarian crisis in Darfur.
6. United Nations Office for the Coordination of Humanitarian Affairs (2024) Sudan humanitarian needs overview 2024.
7. World Health Organization (2023) WHO Sudan situation reports.
8. Raja A, et al. (2025) Early warning alert and response system for Darfur, Sudan. *The Lancet Microbe*: 101147. [Crossref] [Google Scholar] [Indexed]
9. Spiegel PB, Checchi F, Colombo S, Paik E (2010) Health-care needs of people affected by conflict: Future trends and changing frameworks. *The Lancet* 375: 341-345. [Crossref] [Google Scholar] [Indexed]
10. Ratnayake R, Tiban M, Zahiga I, et al. (2020) The need for robust and integrated early warning systems in protracted emergencies: Lessons from the DRC. *BMJ Global Health* 5: e002425.
11. Checchi F, Warsame A, Treacy-Wong V, Polonsky J, van Ommeren M, et al. (2017) Public health information in crisis-affected populations: A review of methods and their use for epidemiological assessment. *The Lancet* 390: 2297-2313. [Crossref] [Google Scholar] [Indexed]
12. WHO (2021) Early warning, alert and response in emergencies: Implementation guide. World Health Organization.
13. Lam E, McCarthy A, Brennan M (2017) Vaccine-preventable diseases in humanitarian emergencies among refugee and internally-displaced populations. *Human Vaccines & Immunotherapeutics* 11: 2627-2636. [Crossref] [Google Scholar] [Indexed]
14. OCHA (2022) Sudan humanitarian needs overview. United Nations.



Nations Office for the Coordination of Humanitarian Affairs.

15. UNICEF (2019) Community-based surveillance and outbreak response in emergency settings. United Nations Children's Fund.
16. Marston C, Renedo A, Miles S (2020) Community participation is crucial in a pandemic. The Lancet 395: 1676-1678. [Crossref] [Google Scholar] [Indexed]
17. WHO, GAVI (2020) Strengthening coordination in disease outbreaks and emergencies. Joint Report.
18. UNICEF Sudan (2024) Sudan: Humanitarian situation report no. 5.
19. Centers for Disease Control and Prevention (2023) Public health surveillance during complex emergencies.