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Assessment of Epidemic Preparedness for Ebola Virus Disease and Hantavirus in the Kokolo Military Health Zone, Democratic Republic of the Congo

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Abstract

The Kokolo Military Health Zone in Kinshasa, comprising 27 militaries-based health areas, plays a critical role in epidemic preparedness within the Armed Forces of the Democratic Republic of the Congo (AFDRC). With the country facing its 17th Ebola Virus Disease (EVD) outbreak since May 15, 2026 characterized by high lethality, insecurity and population mobility and with the emerging threat of Hantavirus in confined military environments, strengthening preparedness and surveillance capacities is essential. This descriptive analysis reviews the epidemiological context of EVD and Hantavirus, assesses the current surveillance and response capacities of the Kokolo Military Health Zone and examines preparedness strategies implemented in coordination with national health authorities. Data sources include surveillance reports, laboratory findings and national outbreak response guidelines. The Kokolo Military Health Zone demonstrated strong epidemiological surveillance performance during the 2022-2025 mpox outbreak, with a 25.2% positivity rate among 202 samples tested in 2024. Preparedness for EVD includes community based early warning systems, strengthened collaboration with the National Institute of Biomedical Research (NIBR), maintenance of personal protective equipment stocks and reinforcement of infection prevention and control measures. Hantavirus preparedness focuses on rodent control, environmental sanitation, staff training and integration of Hantavirus into differential diagnostic panels. Persistent challenges include insecurity near Kwamouth, limited diagnostic tools for rare viral strains and declining international funding. Overall, the Kokolo Military Health Zone has a solid foundation in epidemiological surveillance and outbreak response. However, recurrent Ebola outbreaks and the emerging risk of Hantavirus require continuous capacity strengthening, improved logistical readiness and enhanced collaboration with national and international partners to ensure effective preparedness in military settings.

Keywords: Ebola virus disease; Hantavirus; Military health zone; Epidemiological surveillance; Infection prevention and control; Diagnostic capacity; Outbreak preparedness

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Introduction

The Democratic Republic of the Congo (DRC) remains one of the world's most complex environments for epidemic preparedness and response, owing to its vast geography, persistent insecurity, population mobility and the recurrent emergence of high impact viral pathogens [1]. Among these, Ebola Virus Disease (EVD) continues to pose a major public health threat, with the country having recorded more than fifteen outbreaks since the first identification of the virus in 1976. The most recent outbreak, officially declared on 17th May 2026, represents

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the 17th national episode, affecting multiple eastern provinces including Ituri, North Kivu and South Kivu. This outbreak, associated with the Bundibugyo strain, has been characterized by high lethality, logistical constraints and the challenge of responding in areas marked by armed conflict and population displacement. As of the latest reports, more than 330 suspected cases and 80 deaths have been documented, underscoring the continued vulnerability of the national health system [2,3].

Within this broader national context, the Kokolo Military Health Zone occupies a uniquely strategic position. Located in Kinshasa, the capital city, it encompasses 27 Health Areas, each corresponding to a military camp distributed across the urban landscape. This configuration places the zone at the intersection of civilian and military health dynamics, with implications for both surveillance and outbreak response. Military populations are characterized by high mobility, frequent deployment and close quarter living conditions factors that can accelerate the spread of infectious diseases. Moreover, the presence of dependents, including spouses and children, increases the demographic diversity and epidemiological complexity of the zone. As a result, the Kokolo Military Health Zone functions not only as a clinical and preventive health structure but also as a critical component of national biosecurity [4,5].

In addition to Ebola, the emergence of Hantavirus as a potential threat further complicates the epidemiological landscape. Although Hantavirus infections are rarely reported in Central Africa, global evidence indicates that outbreaks frequently occur in confined or semi-confined environments, including military barracks, training camps and other settings where rodent exposure is common [4]. Transmission typically occurs through inhalation of aerosolized particles contaminated with rodent excreta, making overcrowded or poorly sanitized environments particularly vulnerable. Given that several military camps in Kinshasa face challenges related to waste management, rodent control and infrastructure maintenance, the risk of Hantavirus introduction or amplification cannot be dismissed. The combination of a historically recurrent pathogen such as Ebola and an emerging zoonotic threat such as Hantavirus highlights the need for integrated, multisectoral preparedness strategies.

The Kokolo Military Health Zone has demonstrated significant capacity in recent years, particularly during the 2022-2025 mpox outbreak, during which it maintained active surveillance and contributed to national response efforts. A 2024 analysis of 202 samples revealed a positivity rate of 25.2%, reflecting the zone's ability to detect and report cases efficiently [5]. This experience provides a foundation upon which preparedness for other viral threats can be built. However, the zone's operational environment also presents persistent challenges, including limited diagnostic infrastructure, dependence on centralized laboratory services and the need for continuous training of military health personnel.

Nationally, the Ministry of Health has implemented several strategies to strengthen outbreak response, including the deployment of multisectoral investigation teams, establishment of Ebola treatment centers, decentralization of laboratory services and reinforcement of surveillance systems [6]. The Kokolo Military Health Zone participates actively in these mechanisms, yet its military specific context requires tailored approaches. For example, the constant movement of troops necessitates rapid case detection and immediate isolation capacity, while the hierarchical structure of the armed forces offers opportunities for efficient dissemination of health directives provided that communication channels are well coordinated.

Preparedness for Ebola within the zone includes the establishment of community based early warning systems, training in symptom recognition and collaboration with the National Institute of Biomedical Research (NIBR) for rapid diagnostic confirmation [7]. Logistical readiness such as maintaining stocks of Personal Protective Equipment (PPE), ensuring functional isolation units and securing transport routes for suspected cases remains a priority [8]. However, the absence of an effective vaccine against the Bundibugyo strain limits the applicability of existing immunization strategies such as ring vaccination, which has proven effective for the Zaire strain using Ervebo® [9]. Consequently, infection prevention and control (IPC) measures, including hand hygiene, respiratory hygiene and physical distancing, remain the cornerstone of Ebola preparedness.

Similarly, preparedness for Hantavirus requires a combination of environmental management, rodent control, staff training and diagnostic integration. The Kokolo Military Health Zone has begun incorporating Hantavirus into its differential diagnostic panels and strengthening collaboration with NIBR laboratories to improve detection capacity [10-13]. These efforts are essential given the potential for under recognition of Hantavirus infections in settings where febrile illnesses are common and diagnostic resources are limited.

Despite these advances, significant challenges persist. Insecurity in areas near Kwamouth continues to hinder surveillance activities, while limited diagnostic tools for rare viral strains and declining international funding for epidemic preparedness pose additional constraints [3,14]. Addressing these challenges will require sustained investment, enhanced multisectoral collaboration and the development of preparedness plans specifically adapted to military environments.

This article provides a comprehensive assessment of the Kokolo Military Health Zone's capacities, preparedness strategies and challenges in addressing Ebola Virus Disease and Hantavirus threats. By examining both established and emerging risks, it highlights the critical role of military health systems in national epidemic preparedness and underscores the need for continuous strengthening of surveillance, diagnostics and response mechanisms.

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Methods

This study employed a descriptive, documentary and analytical approach to assess the preparedness of the Kokolo Military Health Zone for Ebola Virus Disease (EVD) and Hantavirus threats. The methodology integrated epidemiological data review, operational analysis and evaluation of existing preparedness measures within the military health system.

Study design

A descriptive cross-sectional design was used to examine surveillance performance, outbreak response mechanisms and preparedness strategies implemented between 2022 and 2026. The study focused on the 27 Health Areas that constitute the Kokolo Military Health Zone, all of which correspond to military camps dispersed across Kinshasa.

Data sources

Data were collected from multiple complementary sources:

- Routine epidemiological surveillance reports from the Kokolo Military Health Zone (2022-2026).
- Laboratory testing records from the National Institute of Biomedical Research (NIBR), including mpox diagnostic data from 2024.
- National outbreak response guidelines issued by the Ministry of Health, particularly those related to EVD, mpox and cholera.
- Minutes and reports from provincial and national coordination meetings involving the Ministry of Health, AFDRC medical services, WHO and MSF.
- International technical documents from WHO, CDC and ECDC on Ebola, Hantavirus and infection prevention and control.

All data sources were reviewed to ensure consistency, completeness and relevance to the objectives of the study.

Data collection procedures

Data extraction followed a structured process. Starting by Compilation of surveillance indicators, including suspected cases, confirmed cases, positivity rates and reporting timeliness. Followed by the review of laboratory capacity, focusing on diagnostic availability, sample referral pathways and collaboration with NIBR. Also, assessment of preparedness measures, including stock levels of Personal Protective Equipment (PPE), isolation capacity, environmental sanitation practices and staff training activities. For finishing with identification of operational challenges, such as insecurity, logistical constraints and gaps in diagnostic tools.

Information was cross validated across sources to minimize reporting bias.

Variables and indicators

Key variables analyzed included:

- **Epidemiological indicators:** Number of suspected cases, confirmed cases, deaths, positivity rates and geographic distribution.
- **Surveillance performance indicators:** Reporting completeness, timeliness and functionality of early warning systems.
- **Preparedness indicators:** Availability of PPE, isolation units, trained personnel, rodent control measures and IPC compliance.
- **Diagnostic indicators:** Availability of EVD and Hantavirus testing, sample turnaround time and laboratory referral mechanisms.

Analytical approach

A qualitative and quantitative descriptive analysis was conducted:

- Quantitative data (positivity rates, case counts) were summarized using proportions and frequencies.
- Qualitative data (preparedness measures, operational challenges) were analyzed thematically to identify strengths, gaps and opportunities for improvement, waiting for probable positive case.
- Findings were interpreted within the broader national context of epidemic preparedness and the specific operational realities of military health settings.

Ethical considerations

This assessment relied exclusively on secondary, aggregated, non-identifiable data from routine surveillance and official reports. No individual level patient data were accessed. Authorization for data use was obtained from the Kokolo Military Health Zone administration and aligned with national public health data sharing policies.

Results

General coordination

Figure 1 illustrates the operational structure of the Ebola and Hantavirus response within the Kokolo Military Health Zone, highlighting an organization built around six essential pillars: Surveillance, case management, laboratory diagnostics, communication, logistic and psychosocial care. At the top of the coordination system, the Chief Zone Doctor provides overall leadership and ensures alignment with national response protocols. This structure demonstrates the zone's capacity to rapidly mobilize alert and investigation teams, conduct systematic contact tracing and implement isolation and treatment measures within dedicated Ebola Treatment Units or for Hantavirus while ensuring adequate protection of healthcare personnel. The laboratory component, coordinated with the National

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Institute of Biomedical Research (NIBR), strengthens diagnostic reliability through secure sample collection, safe transport and timely feedback of results. In the context of this article, the organogram underscores that the Kokolo Military Health Zone has an integrated and functional response system capable of managing recurrent Ebola outbreaks and adapting to emerging threats such as Hantavirus, despite the security and logistical challenges identified.

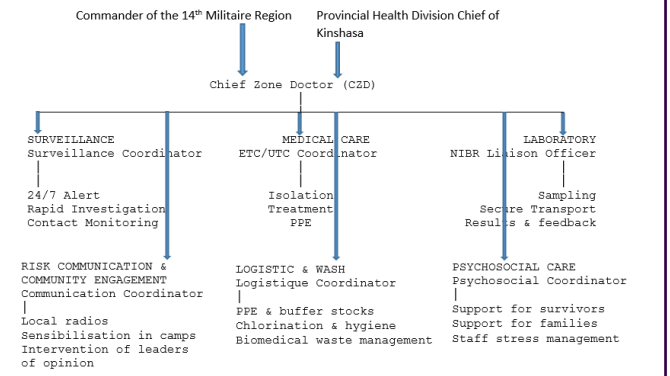

Figure 1: Ebola and hantavirus response coordination organization chart, Kokolo health zone.

Epidemiological surveillance performance

The Kokolo Military Health Zone demonstrated strong surveillance capacity during the study period (2022-2026). Analysis of routine surveillance data revealed that the zone maintained consistent reporting completeness and timeliness, supported by its network of 27 militaries-based Health Areas. During the 2022-2025 mpox outbreak, the zone conducted extensive case detection and laboratory referral. In 2024, 202 samples were tested, of which 25.2% were positive, indicating both active transmission and effective case identification mechanisms. These findings highlight the zone's ability to sustain surveillance activities even during prolonged outbreaks.

Integration into national outbreak response mechanisms

The Kokolo Military Health Zone actively participated in national and provincial coordination structures led by the Ministry of Health. This involvement facilitated deployment of multisectoral investigation teams, establishment and reinforcement of Ebola Treatment Centers, distribution of vaccines and essential medical supplies and decentralization of laboratory services to improve diagnostic turnaround times.

The zone's military command structure enabled rapid dissemination of health directives and facilitated coordination with civilian health authorities.

Preparedness for Ebola virus disease

- **Surveillance and early warning:** The zone strengthened its community based early warning system, enabling rapid detection and reporting of suspected EVD cases. Military health personnel received targeted training on symptom recognition and triage, improving frontline detection capacity.
- **Diagnostic collaboration:** Collaboration with the National Institute of Biomedical Research (NIBR) ensured timely laboratory confirmation of suspected cases. The zone maintained functional sample transport pathways, allowing rapid referral despite logistical constraints.
- **Logistical readiness:** Preparedness assessments showed that the zone maintained adequate stocks of Personal Protective Equipment (PPE), functional isolation units capable of receiving suspected cases and secure transport routes for case evacuation.

These measures supported operational readiness during the ongoing 17th EVD outbreak.

- **Vaccination and infection prevention:** Although Ervebo® is effective against the Zaire strain, it is not effective against the Bundibugyo strain implicated in the current outbreak. Consequently, preparedness efforts focused on strict Infection Prevention and Control (IPC) measures, reinforcement of hand hygiene and respiratory hygiene, physical distancing within military camps and systematic reporting of any suspected EVD or influenza like illness.

The zone is prepared to participate in ring vaccination strategies once appropriate vaccines become available.

Preparedness for Hantavirus

- **Environmental and vector control:** Environmental assessments revealed vulnerabilities related to rodent infestation in certain military camps. In response, the zone implemented rodent control campaigns, improved waste management systems and sanitation of dormitories and storage facilities. Mask use was strongly recommended for individuals presenting with fever and cough.
- **Personnel awareness and training:** Training sessions were conducted to improve understanding of aerosol-based transmission, hygiene practices during cleaning activities and appropriate use of masks and disinfectants.

These measures aimed to reduce the risk of Hantavirus transmission in confined military environments.

- **Diagnostic capacity:** The Kokolo Military Health Zone integrated Hantavirus into its differential diagnostic panels, enabling clinicians to consider the pathogen in cases of unexplained febrile illness. Collaboration with NIBR laboratories was strengthened to ensure access to confirmatory testing and technical support.

Operational challenges identified

Despite progress, several challenges were documented

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Insecurity in areas near Kwamouth limited surveillance and field investigations, limited diagnostic tools for rare viral strains, including Bundibugyo and Hantavirus, constrained rapid detection and declining international funding for epidemic preparedness affected resource availability and sustainability of interventions.

These challenges underscore the need for sustained investment and tailored strategies for military health settings.

Discussion

The coordination structure shown of the Kokolo Military Health Zone highlights the operational readiness by illustrating a clear division of responsibilities across surveillance, case management, laboratory diagnostics, communication, logistic and psychosocial care. This streamlined organization, led by the Zone Medical Officer, enables rapid detection, isolation and confirmation of suspected Ebola or Hantavirus cases, reflecting strong alignment with national response protocols. The organogram demonstrates that Kokolo has an integrated system capable of mobilizing teams efficiently and maintaining collaboration with the National Institute of Biomedical Research. However, the structure also underscores the need for sustained resources and logistical support to maintain performance in the face of recurrent Ebola outbreaks and emerging threats such as Hantavirus.

This assessment highlights the critical role of the Kokolo Military Health Zone in the broader landscape of epidemic preparedness in the Democratic Republic of the Congo. The findings demonstrate that the zone possesses a solid foundation in epidemiological surveillance, strengthened through its experience with the 2022-2025 mpox outbreak, yet continues to face substantial challenges in responding to both recurrent and emerging viral threats. The dual burden of Ebola Virus Disease (EVD) and Hantavirus underscores the need for a comprehensive, adaptable and military specific preparedness strategy.

The strong surveillance performance observed particularly the timely detection and reporting of mpox cases demonstrates the zone's operational capacity and the effectiveness of its reporting structures. This is especially significant given the unique characteristics of military populations, including high mobility, close quarter living conditions and rapid redeployment. These factors can accelerate disease transmission but also offer opportunities for rapid implementation of control measures when command structures are leveraged effectively. The integration of the Kokolo Military Health Zone into national coordination mechanisms further enhances its ability to contribute to outbreak response, ensuring alignment with Ministry of Health strategies and facilitating access to laboratory and logistical support.

Preparedness for EVD remains a central priority, particularly in light of the ongoing 17th outbreak involving the Bundibugyo strain. The zone's efforts to strengthen community based early warning systems, improve diagnostic collaboration with the National Institute of Biomedical Research (NIBR) and maintain stocks of Personal Protective Equipment (PPE) reflect a proactive approach to outbreak readiness. However, the absence of an effective vaccine against the Bundibugyo strain limits the applicability of proven strategies such as ring vaccination, which has been successful for the Zaire strain. This limitation reinforces the importance of Infection Prevention and Control (IPC) measures, including hand hygiene, respiratory hygiene and physical distancing, as the primary defense against transmission in military settings.

The emerging threat of Hantavirus presents an additional layer of complexity. Although not yet documented in the DRC, global evidence shows that Hantavirus outbreaks frequently occur in environments similar to military camps settings where rodent exposure, overcrowding and inadequate sanitation may converge. The Kokolo Military Health Zone's efforts to integrate Hantavirus into differential diagnostic panels and strengthen environmental sanitation are therefore timely and appropriate. These measures not only address the potential risk of Hantavirus but also contribute to broader improvements in environmental health and respiratory disease prevention.

Despite these strengths, several challenges persist. Insecurity in areas near Kwamouth continues to hinder surveillance and field investigations, limiting the zone's ability to detect and respond to potential spillover events. Limited diagnostic tools for rare viral strains, including Bundibugyo and Hantavirus, further constrain rapid detection and confirmation. Additionally, declining international funding for epidemic preparedness threatens the sustainability of ongoing efforts, particularly in resource intensive areas such as laboratory capacity, PPE procurement and staff training.

Addressing these challenges will require sustained investment and a strategic focus on strengthening military health infrastructure. Enhancing laboratory capacity within the military system, expanding training programs for frontline personnel and institutionalizing regular epidemic simulation exercises will be essential to improving readiness. Furthermore, reinforcing collaboration between AFDRC, NIBR, WHO, MSF and other partners will ensure that the Kokolo Military Health Zone remains integrated into national and international preparedness frameworks.

Overall, the findings of this assessment underscore the importance of a military adapted preparedness model that accounts for the unique operational realities of armed forces. As the DRC continues to face recurrent EVD outbreaks and the potential emergence of new zoonotic threats, the Kokolo Military Health Zone stands as a critical pillar of national health security. Strengthening its capacities will not only protect military personnel and their dependents but also contribute significantly to the country's overall epidemic resilience.

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Strengths and Limitations of the Study

Strengths

- **Strong surveillance foundation within a military health system:** The study benefits from data generated within a well-organized network of 27 militaries-based Health Areas, which ensures structured reporting and reliable epidemiological surveillance. This enhances the validity of findings related to outbreak detection and response capacity.
- **Use of multi-source, real world operational data:** The analysis draws on surveillance reports, laboratory records, national coordination documents and international guidelines. This triangulation strengthens the credibility of the findings and provides a comprehensive view of preparedness for Ebola Virus Disease and Hantavirus.
- **Relevance to a high risk, high mobility population:** Military populations are uniquely vulnerable due to mobility, deployment patterns and close quarter living conditions. Studying preparedness in this context provides insights that are highly relevant for national biosecurity and for other military health systems globally.
- **Demonstrated operational experience during recent outbreaks:** The Kokolo Military Health Zone's documented performance during the 2022-2025 mpox outbreak particularly the 25.2% positivity rate among 202 samples provides a strong empirical basis for evaluating current preparedness capacities.
- **Integration into national and multisectoral response mechanisms:** The study captures the zone's active participation in Ministry of Health coordination structures, which strengthens the generalizability of findings to national outbreak response frameworks.

Limitations

Reliance on secondary, aggregated data: The study uses routine surveillance reports and official documents rather than primary field data. This may limit the depth of analysis and may not fully capture under reported cases or operational nuances.

Limited diagnostic capacity at the point of care

The Kokolo Military Health Zone lacks on site diagnostic tools for rare viral strains such as Bundibugyo and Hantavirus. This dependence on external laboratories may introduce delays and affect the completeness of diagnostic data.

Incomplete surveillance coverage due to insecurity

Insecurity in areas near Kwamouth restricts field investigations and may lead to gaps in early detection of spillover events, affecting the representativeness of surveillance findings.

Environmental and infrastructural constraints

Rodent infestation, overcrowding and inconsistent waste management in some military camps may influence the risk of zoonotic transmission. These environmental vulnerabilities may not be fully quantifiable through available data.

Limited generalizability beyond military settings

Because the study focuses on a military population with unique mobility patterns, hierarchical structures and living conditions, findings may not be fully generalizable to civilian health zones.

Declining international funding affecting preparedness indicators

Reduced financial support may influence the sustainability of preparedness activities, including PPE procurement, training and laboratory strengthening. This may affect the long-term applicability of the study's conclusions.

Conclusion

This study demonstrates that the Kokolo Military Health Zone occupies a pivotal position in the Democratic Republic of the Congo's broader system of epidemic preparedness and response. Its structured network of 27 militaries-based Health Areas, combined with its demonstrated surveillance performance during the mpox outbreak, provides a solid operational foundation for addressing both recurrent and emerging viral threats. The zone's integration into national coordination mechanisms and its collaboration with the National Institute of Biomedical Research (NIBR) further reinforce its capacity to respond effectively to Ebola Virus Disease outbreaks, including the ongoing Bundibugyo associated episode.

However, the findings also reveal that preparedness remains fragile in the face of persistent insecurity, limited diagnostic capacity for rare viral strains and declining international funding. These constraints are particularly concerning given the dual threat posed by Ebola and the emerging risk of Hantavirus in military environments characterized by mobility, overcrowding and environmental vulnerabilities. Strengthening laboratory infrastructure, enhancing infection prevention and control practices and institutionalizing regular simulation exercises will be essential to improving readiness.

Ultimately, the Kokolo Military Health Zone represents a critical pillar of national health security. Sustained investment, targeted capacity building and reinforced multisectoral collaboration particularly between AFDRC, NIBR, WHO and MSF will be necessary to ensure that the zone can continue to detect, contain and respond to high

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impact pathogens. By addressing its current gaps and leveraging its existing strengths, the Kokolo Military Health Zone can serve as a model for military adapted epidemic preparedness in the DRC and beyond.

Authors' Contributions

Masamba Bikoki Winnie: Design and writing.

Kiula Ntete Eloi: Design and writing.

Amisi Kengea Levis: Corresponding author design, literature review, data availability, analysis, writing of the report and the article.

Declaration of conflict of interest

No conflict of interest.

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