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Review Article

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Document analysis in Marburg virus outbreak response reports in Africa (2021–2025) to guide future manual updates

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ABSTRACT

Marburg virus disease (MVD) represents a re-emerging public health threat in Africa, with five documented outbreaks across four countries between 2021 and 2025 resulting in 89 cases and 34 deaths. This comparative review examined outbreaks in Guinea (2021, 1 case, CFR 100%), Ghana (2022, 3 cases, CFR 67%), Tanzania (2023 and 2025; 9 and 10 cases, CFR 67% and 100% respectively), and Rwanda (2024, 66 cases, CFR 23%), using WHO Situational Reports, After Action Reviews, and peer-reviewed literature. Analysis across six thematic domains; coordination, surveillance, case management and infection prevention and control (IPC), laboratory diagnostics, risk communication, and logistics/financing revealed progressive strengthening of national response capacities. Coordination evolved from externally led approaches in early outbreaks to structured, government-led multisectoral systems in Rwanda and Tanzania. Surveillance advanced from external laboratory dependence to digital tools and integrated systems, though early case detection and quarantine adherence remain critical gaps. Case management and IPC improved through integration with water, sanitation, and hygiene measures; however, community mistrust and stigma continued to undermine response effectiveness. Risk communication advanced with rumor tracking and targeted campaigns, though inconsistent community involvement limited impact. Financing shifted from donor dependency toward emerging domestic mechanisms and operational tracking. A critical cross-cutting lesson emerged regarding knowledge-sharing platforms. One Health Communities of Practice (OHCoPs) were identified as mechanisms to institutionalize learning, strengthen multisectoral collaboration, and translate recommendations into

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Conflict of Interest

The authors have unanimously declared that they have no competing interests that could have potentially influenced the work reported in this manuscript. Most authors were involved in the conception, design, data collection, analysis, and manuscript preparation in a concerted effort among the various affiliated institutions under the One Health framework. The views and opinions expressed in this manuscript are those of the authors and do not necessarily reflect the official policy or position of their respective institutions or funding organizations. No author has received any financial or personal benefits that could be perceived as influencing the findings or interpretation of the data presented herein.

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practice. While African MVD responses increasingly align with WHO guidance, significant gaps persist in early detection, sustained community engagement, and sustainable financing. Institutionalizing OHCoPs and updating global guidance with recent outbreak lessons will strengthen resilience against future MVD and zoonotic threats.

Keywords: Marburg virus disease; Disease outbreaks; Public health surveillance; Infection control; Risk assessment; One Health

INTRODUCTION

Marburg virus (MARV) is a highly pathogenic zoonotic RNA virus that causes Marburg virus disease (MVD), a severe hemorrhagic fever with a high fatality rate ranging from 24% to 88%.[1-4] Since 2014, some African countries have been affected, where Uganda and Tanzania have had it multiple times, with 133 cases and 73 deaths. Tanzania (2025) 10 cases case fatality rate (CFR) 100%, Rwanda (2024) 66 cases CFR 23%, Tanzania (2023) 9 cases, CFR 67%, Ghana (2022) 3 cases CFR 67%, Equatorial Guinea (2022) 40 cases CFR 88%, Guinea (2021) 1 case CFR 100%, Uganda (2017) 3 cases CFR 100% Uganda (2014) 1 case CFR 100%.[5,6] The role of the World Health Organization (WHO) and global health security partners aimed at prevention of outbreak, enhanced surveillance and response, infection prevention and control (IPC), case management, logistic, risk communication and community engagement (RCCE), coordination and governance, surveillance, risk communication, community engagement, laboratory, continuity of essential services, case management, strategic information, research and innovations.

The virus belongs to the *Filoviridae* family, closely related to the *Orthoebolavirus genus*, and is known for its potential to cause significant outbreaks with high mortality rates.[3,4,7] The virus spreads to humans through direct contact with infected bats, primarily the Egyptian fruit bat (*Rousettus aegyptiacus*), or their secretions.[2,8,9] Human-to-human transmission occurs via direct contact with the bodily fluids of infected individuals or contaminated objects.[1,4,9] The incubation period ranges from 2 to 21 days,[2,4] with initial symptoms including fever, headache, and myalgia, progressing to severe hemorrhagic manifestations, multi-organ failure, and shock.[4,7,10]

The virus targets immune and endothelial cells, leading to immune dysregulation, cytokine storm, and coagulopathy.[10,11] The first recorded MVD outbreak occurred in 1967 in Germany and Serbia due to laboratory exposure to infected African green monkeys, and subsequent outbreaks have been reported in various African countries, including Uganda, Angola, Democratic Republic of the Congo, Kenya, and, more recently, in Tanzania and Equatorial Guinea in 2023, and Rwanda in 2024.[4,8,12,13] MVD presents numerous challenges that complicate its management and containment, including challenges related to public health (high mortality, rapid progression, limited healthcare infrastructure),[10,14,15] diagnosis (nonspecific early symptoms, lack of rapid diagnostic tools),[16,17] treatment (no licensed vaccines/treatments, ethical/logistical challenges in testing),[10,18] psychological and social (mental health impact, stigma, disruption of traditional practices),[19] as well as containment and surveillance (need for robust surveillance, cross-border spread).[14,20]

Given its severe impact, especially in resource-limited settings, the importance of prevention and preparedness strategies for MVD cannot be overstated. Implementing strict

IPC measures can significantly reduce the spread of the virus. These measures include developing guidelines, conducting facility assessments, and ensuring proper training and supervision of healthcare workers. Strengthening healthcare infrastructure and ensuring the availability of necessary supplies and equipment are also vital for effective IPC.[21] In addition, educating the public about MVD and promoting proper hygiene practices can help prevent outbreaks. Raising awareness about the risks and transmission routes of MVD can lead to better community cooperation and adherence to preventive measures. Furthermore, collaboration between governments, international organizations, and local communities is essential for a coordinated response to MVD outbreaks.[22,23]

The WHO plays a multifaceted role in the prevention and control of MARV outbreaks. As part of the prevention and preparedness, the WHO supports the enhancement of surveillance systems to ensure early detection of outbreaks,[24,25] prioritizes the development of vaccines and treatments for the MVD,[26] as well as advocates for policy reforms and structural changes to improve global health governance.[27,28] Further, the WHO's role extends to global health security, where it helps countries build capacities to manage health emergencies. For example, Uganda's implementation of the Global Health Security Agenda aligns with WHO benchmarks to strengthen outbreak response capabilities.[29] The WHO's role in the outbreak response includes providing critical emergency medical supplies and expertise to affected regions. For instance, during Rwanda's first Marburg outbreak, the WHO was instrumental in supplying emergency medical resources and expertise to manage the situation effectively.[24] In Angola, a mobile laboratory unit provided specific MARV diagnostics, significantly aiding in patient management and epidemiological surveillance.[30]

The WHO also worked alongside Médecins Sans Frontières and the Angolan Ministry of Health to implement comprehensive outbreak control measures, including clinical assessment, patient isolation, and safe burials.[31] Following outbreaks, the WHO has developed manuals and conducts After Action Reviews (AARs) to capture lessons learned and improve preparedness. The AARs are critical for evaluating the response to outbreaks and identifying areas for improvement. They involve a systematic examination of the functions, capabilities, and barriers encountered during the response.[32] However, there is often a disconnect between field experiences and updates to formal guidelines.

This study aims to critically review and analyze existing MVD prevention strategies as outlined in the AAR reports and related WHO documentation. By comparing the insights and recommendations derived from past outbreak responses with the most recent version of the WHO manual for MARV prevention and control, this study seeks to identify gaps, overlaps, and opportunities for improvement. Ultimately, the goal is to formulate evidence-based recommendations for updating and strengthening the WHO manual to enhance global preparedness and response to future Marburg outbreaks.

METHODS

This documentary review study was undertaken to analyse follow-up reports of current management systems and real-world response cases, given that MVD had become epidemic in other countries since its outbreak in Uganda in 2017. The study employed a qualitative document review and comparative analysis approach to evaluate the alignment between lessons learned from past MVD outbreaks and the latest WHO manual for prevention and control.

The data sources include the AAR reports, country situation reports and publications from confirmed Marburg outbreaks in four different countries of Guinea, Ghana, Tanzania, and Rwanda from 2021 to 2025; the latest WHO outbreak reports and technical guidance, as well as the IPC guideline for Ebola and Marburg diseases.

The country documents were reviewed side by side. A comparative tabular matrix was developed using Microsoft Excel. Relevant data from each source were manually extracted to capture country, outbreak period, cases/deaths, AAR or published reports and the corresponding pillars including prevention measures implemented, operational challenges encountered, and recommendations for future outbreaks. These documents were freely available on web-based platforms, making them easily referenced. Data was coded in categories deductively as presented in the reports and plans.

Furthermore, a comparative analysis was conducted in three steps: review of published AAR reports by identifying recurrent themes, lessons learned, and challenges in outbreak responses, cross-comparison with WHO outbreak reports by assessing consistency between field experiences and WHO's broader technical guidance, and comparison with the WHO manual by mapping of AAR and outbreak report findings against current manual recommendations to identify gaps, outdated content, or areas requiring expansion.

Extracted data were cross-checked with multiple sources to ensure consistency and minimize bias. Peer-reviewed literature was referenced at the end of the manuscript, including WHO, US Centers for Disease Control and Prevention, and other credible publishing sites.

These reports were in English version and need no translation. Therefore, the inclusion criteria for the country was based on evidence of Marburg outbreaks between 2021–2025, WHO published AAR report, and peer-reviewed literature, and the country was excluded if it missed all the three components.

RESULT

In this review, five reports from four countries, including Tanzania, Rwanda, Ghana, and Guinea, published in the last 5 years, were analyzed. Three countries, i.e., Tanzania in 2025, Rwanda, and Guinea, provided comprehensive reports that were available online, while reports from Tanzania in 2023 and Ghana in 2022 were brief and available from the WHO website (**Table 1**).[33-37]

Table 1. Summary of reports analyzed in this study

Country	Outbreak period	Cases/deaths	AAR or published reports
Tanzania	20 January–13 March 2025	2 confirmed cases and 8 probable cases; 10 deaths	*Response to Marburg Virus Disease Outbreak in Tanzania - 2025*[33]
Rwanda	27 September–20 December 2024	66 confirmed cases; 15 deaths	*After Action Review (AAR) of Marburg Virus Disease Outbreak Response in Rwanda*[34]
Tanzania	21 March–2 June 2023	8 confirmed cases and 1 probable cases; 6 deaths	Lessons from Marburg response to sharpen emergency response in Tanzania[35]
Ghana	7 July–16 September 2022	3 confirmed cases; 2 deaths	Disease outbreak news: Marburg virus disease - Ghana[36]
Guinea	3 August–16 September 2021	1 confirmed case; 1 death	*(WHO, 2021 #36)*[37]

AAR = After Action Review.

The reports were then compared based on the country responses to the outbreak by analyzing 6 themes: 1) coordination and leadership; 2) surveillance and epidemiological investigation; 3) laboratory and diagnostics; 4) case management and IPC; 5) RCCE; and 6) logistics, operation support, and resource mobilization (**Table 2**). Challenges, lessons learned, and recommendations from the outbreak response were also compared between each report (**Table 3**).

The coordination and leadership of Guinea in 2021 and Ghana in 2022 to respond Marburg outbreak focused on rapid declaration and initial capacity building, while Rwanda in

Table 2. Summary of Marburg outbreak response from 5 documents

Category	Tanzania (2025)	Rwanda (2024)	Tanzania (2023)	Ghana (2022)	Guinea (2021)
Coordination and leadership	Strong national leadership; WHO advocacy led to outbreak declaration; IMS-led coordination; daily field meetings, weekly national task force; 17 experts deployed; response plans, SOPs, contingency plans; strong resource mobilization (GAVI, FCDO)	National PHEOC activated; multisectoral coordination; daily meetings; aligned partner support; national response plan developed	Rapid regional activation; high-level government commitment; regular partner info sessions; unified command inconsistencies; clinicians & specialists deployed; corrective action plan developed	Declared outbreak after lab confirmation; national coordination with WHO, CDC, UNICEF, FCDO; IDSR guided response.	Outbreak declared rapidly; WHO activated IMS; daily prefectural coordination; bi-weekly WHO teleconferences; 19 staff deployed; response pillars defined
Surveillance and epidemiological investigation	Enhanced case detection; rapid deployment of field epidemiology teams; strong contact tracing with RCCE integration; ERF indicators tracked daily; multi-sector/ aligned surveillance pillars; 49 sitreps	Strengthened active case finding; community surveillance activated; RRTs deployed; digital alert/ monitoring tools	Late index case detection; mobile lab enabled rapid confirmation; challenges with home quarantine; surveillance reports regularly produced	IDSR implemented; 3 cases (same household); 198 contacts followed for 42 days; all alerts tested	173 contacts traced; community alerts investigated; cross-border collaboration with Sierra Leone & Liberia; 50+ alerts investigated
Laboratory and diagnostics	Rapid field diagnostics; national + regional labs; WHO experts deployed; strengthened SOPs & biosafety; ERF monitoring	National reference lab testing; biosafety support by WHO; cross-border sample transport system	Mobile lab drastically reduced turnaround; national public health lab confirmed cases; strong biosafety; national capacity strengthened	NMIMR testing; confirmation at Institut Pasteur Dakar; genomic sequencing performed	Samples tested locally; final confirmation at Institut Pasteur Dakar; limited district capacity; biosafety supported by WHO
Case management and IPC	Case management pillar active; guidelines & SOPs updated; IPC/ WASH supported; daily monitoring; surge capacity in Biharamulo	Case management sites activated; RRTs trained; IPC support via lab biosafety; facility-level details limited	4 admitted, 75% survival; strong adherence to clinical guidelines; trained specialists; IPC audits; PPE & equipment available; weak home isolation adherence; PHEOC limitations	Isolation center used; HCWs sensitized on IPC; supportive care; 3 cases total, CFR 67%; safe burial messaging	Only 1 confirmed case (fatal); IPC kits to 32 facilities; initial IPC compliance < 10%; hygiene committees reactivated; 2 safe burials, 44 deaths swabbed (all negative except index case)
RCCE	RCCE teams deployed; strong advocacy, media/ website communication; rumor management via daily info-sharing; high-level visibility maintained	Community leaders engaged; radio/ mobile vans/social media used; tailored messages; rumor tracking recommended; strong IEC	Limited community involvement; partner-focused communication; less structured RCCE; some stigmatization concerns	Community-based surveillance volunteers trained; education on wildlife avoidance, safe burials, hand hygiene; communication to reduce stigma	Local leaders, CHWs mobilized; radio communication; rumor management; safe burial messaging
Logistic, operation support, and resource mobilization	17 experts deployed across pillars; daily OSL meetings; ERF financial tracking; GAVI/ FCDO proposals; updated SOPs; integrated capacity-building	Partner-supported logistics; PPE/lab supplies provided; sample transport improved; regional readiness plans activated	Early MoH domestic funding allowed rapid logistics; specialist deployment; partner-supported IPC supplies; mobile lab improved system performance	IPC supplies delivered by MoH + partners; safe patient/sample transport; partner financial support; NMIMR sequencing capacity strengthened	WHO emergency funds (USD 500k) supported majority of logistics; PPE & WASH kits supplied; water points rehabilitated; ambulances/ sample transport supported

WHO = World Health Organization; IMS = Incident Management System; SOPs = standard operating procedures; GAVI = Global Alliance for Vaccines and Immunization; FCDO = Foreign, Commonwealth & Development Office (UK Government); PHEOC = Public Health Emergency Operations Centre; CDC = United States Centers for Disease Control and Prevention; UNICEF = United Nations International Children's Emergency Fund; IDSR = integrated disease surveillance and response; RCCE = risk communication and community engagement; ERF = Emergency Response Framework; RRT = rapid response team; IPC = infection prevention and control; WASH = water, sanitation, and hygiene; HCW = health care worker; CFR = case fatality rate; CHW = community health worker; OSL = operations support and logistics; PPE = personal protective equipment; MoH = Ministry of Health; NMIMR = Noguchi Memorial Institute for Medical Research; USD = United States Dollar.

Table 3. Monitoring, evaluation, lessons learned, challenges, and recommendations

Category	Tanzania (2025)	Rwanda (2024)	Tanzania (2023)	Ghana (2022)	Guinea (2021)
Monitoring & reporting	49 daily WHO internal sitreps produced; ERF indicators tracked response progress; operational research included.	AAR workshop convened; thematic analysis of best practices and gaps; monitoring through joint review.	AAR conducted; corrective action plan developed and shared with policymakers.	Regular MoH situation reports shared with WHO & partners; outbreak declared over after 42 days (WHO criteria).	Daily situation reports produced; WHO teams monitored IPC & WASH; field assessments conducted.
Lesson learned	Strong IMS-led coordination; multi-pillar deployment; clear ERF-linked monitoring and donor engagement.	Strong RCCE & cross-border collaboration; timely lab response; digitalized sample tracking.	Quick activation at regional level; MoH rapid disbursement of funds; strong adherence to treatment guidelines → 75% survival among admitted cases.	Early lab confirmation; effective partner coordination; community surveillance contributed to containment.	Rapid engagement of WHO; IPC kits improved facility readiness; safe burial protocols effective.
Challenges	Sustaining funding and public confidence; need to balance national leadership with partner coordination.	Rumors and misinformation; need for more sustained RCCE investment; capacity gaps in multisectoral engagement.	Late detection of index cases; weak home quarantine adherence; limited unified command in some phases.	High CFR (67%); limited domestic financing; stigmatization risk in communities.	Low baseline IPC capacity (< 10% compliance before intervention); reliance on external labs.
Recommendations	Institutionalize ERF indicator tracking; expand operational research; develop sustainable funding mechanisms (beyond emergency proposals).	Establish permanent rumor-tracking & RCCE systems; invest in regional logistics hubs; sustain cross-border preparedness.	Improve early detection at lower-level facilities; strengthen PHEOC functionality; broaden multisectoral involvement.	Build local genomic sequencing capacity; expand domestic funding; intensify community engagement to reduce stigma.	Strengthen district IPC capacity; invest in local lab infrastructure; maintain hygiene committees beyond outbreak.

WHO = World Health Organization; ERF = Emergency Response Framework; AAR = After Action Review; MoH = Ministry of Health; IPC = infection prevention and control; WASH = water, sanitation, and hygiene; IMS = Incident Management Systems; RCCE = risk communication and community engagement; CFR = case fatality rate; PHEOC = Public Health Emergency Operations Centre.

2024 emphasized a highly structured Public Health Emergency Operation Center (PHEOC)-led response with digital tools. In Tanzania's 2023 Marburg outbreak, the country showed improved speed and government commitment, but with gaps in unified command. Those gaps were improved when the country experienced another outbreak in 2025, where it showed strong advocacy, high-level political involvement, detailed standard operating procedures (SOPs), and large-scale partner coordination (**Supplementary Table 1**).

The second theme consisted of the surveillance and epidemiological investigation in the Marburg outbreak response from 5 periods. Both Guinea and Ghana, in 2021 and 2022, respectively, focused on containment of small outbreaks with extensive contact tracing and cross-border vigilance. Tanzania showed delays in initial case detection but strong laboratory confirmation support in 2023, and Rwanda demonstrated modern surveillance tools (digital, real-time) in 2024. Further, Tanzania advanced to integrated surveillance within Incident Management Systems (IMS), with daily situation reports and broader readiness assessments when the outbreak hit the country in early 2025 (**Supplementary Table 2**).

Both Guinea and Ghana relied on external labs (Institut Pasteur Dakar) for confirmation and sequencing. Tanzania in 2023 advanced with a mobile lab that accelerated detection, while Rwanda in 2024 emphasized cross-border lab transport systems. Further, the latest Marburg outbreak in Tanzania (2025) showcased the most mature system, with laboratory SOPs, biosafety, readiness assessments, and international expert support (**Supplementary Table 3**).

Analysis of the case management and IPC of the 5 reports showed that early outbreaks (Guinea in 2021 and Ghana in 2022) focused on basic IPC kits, isolation, and safe burial practices, while from Tanzania in 2023 onwards, stronger clinical management outcomes and specialist support were evident. Rwanda in 2024 and Tanzania in 2025 highlighted

systematized training, integration with RCCE/ water, sanitation, and hygiene (WASH), and operational research for IPC (**Supplementary Table 4**).

Guinea, Ghana, Rwanda, and Tanzania in 2025 all invested in community-level RCCE (leaders, radio, volunteers, advocacy). Tanzania in 2023 lagged behind in structured RCCE, relying mainly on technical/partner updates. Further, Rwanda (2024) and Tanzania (2025) advanced with rumor tracking systems, tailored information, education, and communication (IEC), and high-level advocacy products (**Supplementary Table 5**).

In terms of logistics, operation support, and resource mobilization, Guinea in 2021 relied almost entirely on WHO logistics and financing. Ghana's logistics, on the other hand, were mainly partner-driven, with domestic financing less visible. In 2024, Rwanda strengthened regional logistics and cross-border sample transport. While in 2023 Tanzania stood out for timely domestic funding, which was enabling early logistics, in 2025 the country integrated operations support and logistics and finance pillar, Emergency Response Framework (ERF) indicator tracking, as well as partner funding proposals (Global Alliance for Vaccines and Immunization/Foreign, Commonwealth & Development Office) (**Supplementary Table 6**).

The 5 reports showed that countries improved monitoring/reporting progressively from basic Situational Reports in Guinea (2021) to ERF-linked, research-oriented monitoring in Tanzania (2025). Challenges faced were consistent, including weak early detection, limited domestic financing, community mistrust, and over-reliance on external partners. Recommendations proposed were to strengthen domestic laboratory and IPC systems, sustain multisectoral and RCCE, as well as institutionalize evaluation frameworks (AAR, ERF indicators) (**Table 3**).

DISCUSSION

Historical context of MVD outbreaks

To understand how MVD preparedness and response have evolved in Africa, it is important to examine the global history of outbreaks. **Fig. 1** presents a timeline from 1967 to 2025, highlighting where outbreaks occurred, how many people were reported and associated fatality rates.

This timeline shows how MVD has evolved over six decades, beginning with its 1967 outbreak in Europe linked to Ugandan Monkeys, highlighting its zoonotic origin. Later outbreaks in Kenya (1980 and 1987), the Democratic Republic of Congo (1998–2000), and Angola (2005) demonstrated the recurring presence in East and Central Africa and consistently high fatality rates, often exceeding 80%.

Recent MVD outbreaks in Uganda (2007, 2012, and 2017), Guinea (2021), Ghana (2022), Equatorial Guinea (2023), Tanzania (2023 and 2025), and Rwanda (2024) reflect a geographic expansion and increased frequency of events, likely attributed to enhanced surveillance and detection, diagnostic capacities, under one health approach, strategic reporting and response in accordance to 7-1-7 framework.

The outbreaks (2021–2025) reflects national capacities for coordinated response and integrated surveillance, demonstrated government-led using One Health approach compared

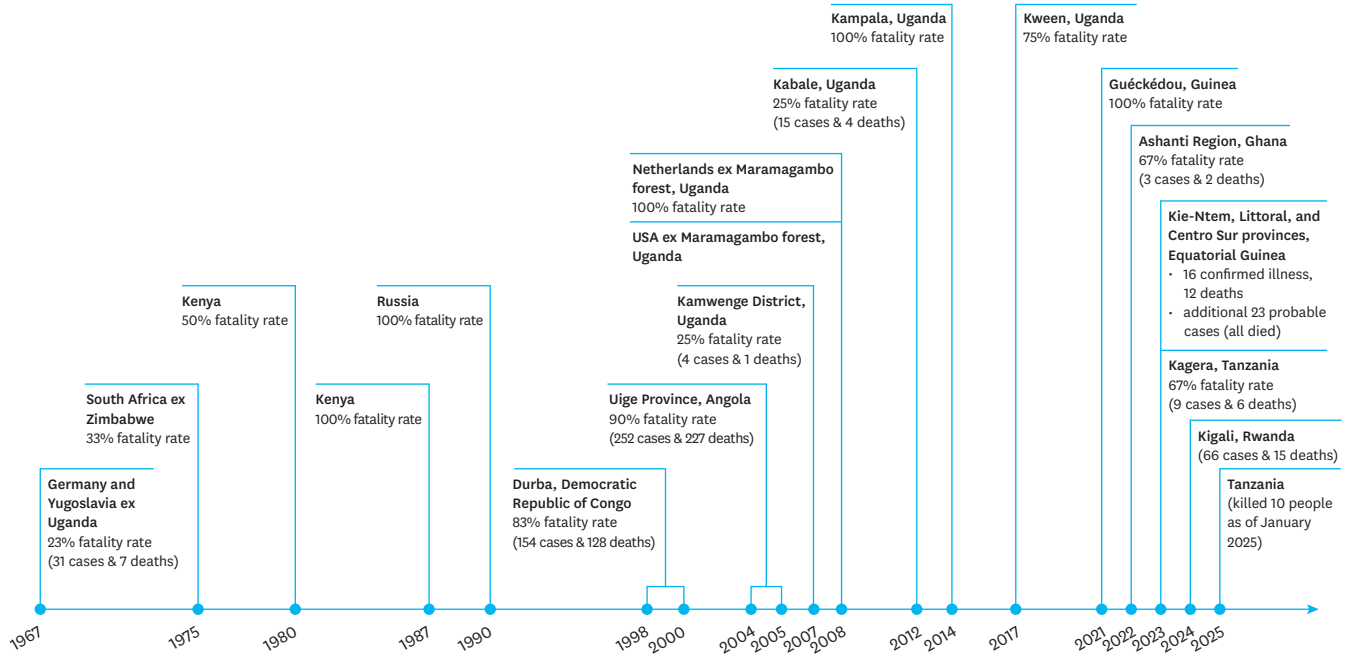

Fig. 1. History of Marburg 1967–2025 (original text by the CDC[6] and modified into a figure).
CDC = United States Centers for Disease Control and Prevention.

to earlier reliance on international partner. The low fatality rates such as in Kabale, Uganda (2007) and Kagera, Tanzania (2023) demonstrates improved efforts in case management, IPC, and community engagement.

Despite progress, high fatality rates in several events (e.g., Equatorial Guinea, 2023; Kween, Uganda, 2017) highlights challenges such as delayed detection, limited laboratory access, and community mistrust. These trends therefore emphasize the need for sustained investments in surveillance infrastructure, response capabilities, and institutionalized knowledge-sharing mechanisms such as One Health Community of Practice (OHCoP) and emergency operation centres (EOCs), to strengthen preparedness and response for future outbreaks at sub-national and national level.

National response capacity and coordination

This review demonstrates an evolution in MVD outbreak coordination 2021 and 2025 where Guinea (2021) and Ghana (2022) relied heavily on externally driven coordination, while Rwanda (2024) and Tanzania (2025) showcased more structured, government-Led, and multi-sectoral responses approach. These findings emphasize the evidence of a strong Public Health Expertise in IMS and functional Public Health Emergency Operations Centers (PHEOCs) that are critical for timely and coordinated outbreak control.

Surveillance and early detection

Surveillance systems have progressively improved, shifting dependence on external expertise, reference laboratories, later incorporated digital reporting tools as seen in Rwanda (2024) and IMS-linked surveillance as seen in Tanzania (2025). These align with global best practices for decentralized expertise, laboratory capacity, digital reporting, and real-time epidemiological analysis. Nonetheless, challenges like delayed detection, poor quarantine compliance, and weak early-warning systems remain a critical gap.

Case management and IPC

Case management and IPC practices evolved from basic isolation, safe and dignified burials to include systematic training in emergency medical teams, operational research, and integration of IPC with WASH, aligning with WHO's recommendations. However, persistent community mistrust and stigma undermines effectiveness of case management, emphasizing the need for culturally sensitive approaches.

RCCE

RCCE capacity improved noticeably, in Rwanda and Tanzania (2025), through rumor tracking and tailored IEC campaigns, while Tanzania's 2023 outbreak showed the consequences of weak community engagement. This emphasizes the importance of institutionalizing RCCE as misinformation and stigma remains key obstacles to effective outbreak control.

Logistics, financing and sustainability

Logistics and resource mobilization have advanced from donor-led efforts in Guinea to integrated domestic financing and tracking in Tanzania (2025). Strengthening National financing mechanisms and institutionalized evaluation frameworks, such as AARs and ERF indicators is vital for resilience in line global health security recommendations promoting country ownership and sustainable financing.

Knowledge sharing and OHCoPs

Recent AARs highlights the importance of sustained knowledge sharing platforms like OHCoPs to foster cross sector collaboration. WHO initiatives and Uganda's regional EOCs, shows how such platforms can support continuous learning and operationalize International Health Regulations (2005) principles, shifting outbreak response from reactive to resilient.

Limitations

This review is constrained by its reliance on secondary sources, a few published AAR reports on WHO websites, amidst declaration of outbreaks in some countries and those published lacking details on political and community level factors, the role of regional EOCs, District Alert Desks and application of 7-1-7 framework in reference to the outbreaks. Despite these limitations, the comparative approach provides valuable insights into evolving response capacities across countries. The inadequate ecological data linkages and limited scope of animal reservoirs safe for bats and monkeys could be a missing link, hence more efforts and increased scope in future research.

Conclusion

National responses to MVD outbreaks in Africa between 2021 and 2025 show progressive alignment with WHO guidance, particularly in IMS, surveillance, IPC, RCCE, and logistics. Persistent gaps remain in early case detection, sustained RCCE, domestic financing, and integration of operational research into outbreak manuals. Addressing these gaps requires both technical strengthening and institutionalized learning through OHCoPs, coupled with regular updates of WHO's Marburg prevention and control manual. These measures will better prepare African countries for future MVD and other high-threat zoonotic outbreaks.

Based on the comparative analysis of MVD outbreaks between 2021 and 2025, several key recommendations emerge for policy and practice and including;

- Strengthening national coordination is vital, with Countries urged to shift toward government-led, multi-sectoral response anchored on functional IMS and PHEOCs to

ensure effective timely outbreak control.
- Enhancing surveillance and early detection is crucial, requiring decentralized laboratory capacity, digital reporting, real-time analysis and improved early-warning mechanisms to identify signals, alerts and enforcing appropriate quarantine measures.
- IPC should be institutionalized beyond outbreaks by integrating with WASH, training and research, to standardize practices and strengthen resilience in resource-limited settings.
- RCCE should be a core preparedness function, with structured community engagement, using rumor-tracking systems, culturally sensitive communication strategies, and stigma-reduction to build trust and ensure compliance.
- Sustainable domestic financing is essential, with countries urged to establish predictable financing tracking systems to reduce donor reliance and ensure continuity in outbreak preparedness and response.
- Institutionalizing OHCoPs enables learning across sectors, systematic sharing of Early Action Reviews, Intra-Action Reviews and AARs insights, and sustained engagement through hybrid virtual platforms and in-person sessions to strengthen outbreak preparedness.

These recommendations emphasize integrating outbreak response capacities within broader health systems strengthening efforts to enhance preparedness for future MVD events, and support regional and global health security.

This comparative review of MVD outbreaks across Africa from 2021 to 2025 highlights both encouraging progress and ongoing areas of improvement in outbreak preparedness and response. National capacities have shifted from relying on external coordination to more organized, government-led, and multi-sectoral responses, increasingly following WHO guidance. Improvements are visible in surveillance, IPC, risk communication, and logistics, but key challenges still exist in early case detection, sustained community engagement, and funding. A central insight from recent AARs is the importance of institutionalizing cross-sectoral knowledge exchange. Establishing OHCoPs offers a practical and sustainable approach to consolidating lessons learned, strengthening collaboration across human, animal, and environmental health, and ensuring that experiences are systematically translated into practice.

Overall, this study recommends OHCoPs as an innovative mechanism for resilience-building. Regularly updating the WHO Marburg prevention and control manual with these lessons, coupled with sustained investment in national systems, will be essential to ensure that countries move beyond reactive crisis management toward proactive preparedness for future potential high-threat zoonotic disease outbreaks.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1
Coordination and leadership in Marburg outbreak response

Supplementary Table 2
Surveillance and epidemiological investigation in Marburg outbreak response

Supplementary Table 3
Laboratory and diagnostics in Marburg outbreak response

Supplementary Table 4
Case management and IPC in Marburg outbreak response

Supplementary Table 5
RCCE in Marburg outbreak response

Supplementary Table 6
Logistic, operation support, and resource mobilization in Marburg outbreak response

REFERENCES

1. Islam MA, Adeiza SS, Amin MR, Kaifa FH, Lorenzo JM, Bhattacharya P, et al. A bibliometric study on Marburg virus research with prevention and control strategies. *Front Trop Dis* 2023;3:1068364. CROSSREF
2. Ofori EK, Nyarko ENY. Chapter 11. Current advances in Marburg virus disease. In: Amponsah SK, Shegokar R, Pathak YV, editors. *Rising Contagious Diseases: Basics, Management, and Treatments*. Hoboken, NJ, USA: Wiley; 2024, 129-44.
3. Yu J, Wei H. Marburg virus. In: Liu D, editor. *Molecular Detection of Animal Viral Pathogens*. Boca Raton, FL, USA: CRC Press; 2016, 507-17.
4. Asad A, Aamir A, Qureshi NE, Bhimani S, Jatoi NN, Batra S, et al. Past and current advances in Marburg virus disease: a review. *Infez Med* 2020;28(3):332-45. PUBMED
5. World Health Organization (WHO). Marburg virus disease. https://www.who.int/news-room/fact-sheets/detail/marburg-virus-disease. Updated 2025. Accessed November 20, 2025.
6. United States Centers for Disease Control and Prevention (CDC). History of Marburg outbreaks. https://www.cdc.gov/marburg/outbreaks/index.html. Updated 2025. Accessed August 11, 2025.
7. Mehedi M, Groseth A, Feldmann H, Ebihara H. Clinical aspects of Marburg hemorrhagic fever. *Future Virol* 2011;6(9):1091-106. PUBMED | CROSSREF
8. Kinimi E. Marburg virus disease in Sub-Saharan Africa: a review of currently available comprehensive genomic data up to 2024. *Zoonotic Dis* 2025;5(1):6. CROSSREF
9. Yang J. Marburg virus disease outbreak in Guinea, August 2021. *Glob Biosecur* 2022;4(1):140. CROSSREF
10. Francis DL, Reddy SSP, Logaranjani A, Sai Karthikeyan SS, Rathi M. Marburg virus disease: pathophysiology, diagnostic challenges, and global health preparedness strategies. *Ann Glob Health* 2025;91(1):24. PUBMED | CROSSREF
11. Siddig EE, Ndembi N, Ahmed A, Muvunyi CM. Immunogenicity, pathogenesis, and host's immuno-responses to Marburg virus infection. *Pathogens* 2025;14(4):323. PUBMED | CROSSREF
12. Shanmugaraj B. Marburg virus: an emerging global threat. *J Zoonotic Dis* 2024;8(4):603-9. CROSSREF

13. Letafati A, Fakhr SSH, Najafabadi AQ, Karami N, Karami H. Marburg virus disease: a narrative review. *Health Sci Rep* 2025;8(5):e70669. PUBMED | CROSSREF
14. Gashugi Y, Byiringiro LB, Rukundo J, Izabayo J, Sezibera V, Kalisa J. Marburg virus disease outbreak in Rwanda, 2024: Current efforts and calls to action to mitigate the outbreak in Rwanda. *Rwanda Public Health Bull* 2024;5(4):7-15. CROSSREF
15. Mustafa N, Rahman JU, Omame A. Modelling of Marburg virus transmission dynamics: a deep learning-driven approach with the effect of quarantine and health awareness interventions. *Model Earth Syst Environ* 2024;10(6):7337-57. CROSSREF
16. Nsekuye O, Ntabana F, Mucunguzi HV, El-Khatib Z, Remera E, Makayotto L, et al. Refining early detection of Marburg virus disease (MVD) in Rwanda: leveraging predictive symptom clusters to enhance case definitions. *Int J Infect Dis* 2025;156:107902. PUBMED | CROSSREF
17. Irkham I, Ibrahim AU, Pwavodi PC, Nwekwo CW, Hartati YW. CRISPR-based biosensor for the detection of Marburg and Ebola virus. *Sens Biosensing Res* 2024;43:100601. CROSSREF
18. Shifflett K, Marzi A. Marburg virus pathogenesis - differences and similarities in humans and animal models. *Virol J* 2019;16(1):165. PUBMED | CROSSREF
19. Gashugi Y, Byiringiro LB, Rukundo J, Izabayo J, Umuhire SI. Mental health impacts of Marburg virus disease in Rwanda. *Rwanda Public Health Bull* 2024;5(4):16-23. CROSSREF
20. Scarpa F, Bazzani L, Giovanetti M, Ciccozzi A, Benedetti F, Zella D, et al. Update on the phylodynamic and genetic variability of Marburg virus. *Viruses* 2023;15(8):1721. PUBMED | CROSSREF
21. Kinyenje E, Hokororo J, Ngowi R, Kiremeji M, Mnunga E, Samwel A, et al. Infection prevention and control of highly infectious pathogens in resource-limited countries: an experience from Marburg viral disease outbreak in Kagera Region - Tanzania. *BMC Infect Dis* 2024;24(1):628. PUBMED | CROSSREF
22. Gulumbe BH, Uggh IHP, Shehu A, Winchislaus E. Marburg virus in Tanzania: examining emergence, consequences, and mitigation approaches. *Healthc Low Resour Settings* 2024;12(2):11355. CROSSREF
23. Hussein MF, Abdu SMM, Gebreal A, Elnagar F, El Demerdash BE, Abonazel MR, et al. Developing and validating of an English questionnaire to assess knowledge, attitudes, and practices regarding Marburg virus disease (EKAP-MVD): a cross-sectional study. *Medicine (Baltimore)* 2025;104(8):e41571. PUBMED | CROSSREF
24. Edward M. Marburg virus in Rwanda: challenges, strategies, and future directions. *Discov Public Health* 2025;22(1):87. CROSSREF
25. Liu Q, Liu M, Liang W, Li X, Jing W, Chen Z, et al. Global distribution and health impact of infectious disease outbreaks, 1996-2023: a worldwide retrospective analysis of World Health Organization emergency event reports. *J Glob Health* 2025;15:04151. PUBMED | CROSSREF
26. Marzi A, Jankeel A, Menicucci AR, Callison J, O'Donnell KL, Feldmann F, et al. Single dose of a VSV-based vaccine rapidly protects macaques from Marburg virus disease. *Front Immunol* 2021;12:774026. PUBMED | CROSSREF
27. Park C. Lessons learned from the World Health Organization's late initial response to the 2014-2016 Ebola outbreak in West Africa. *J Public Health Africa* 2022;13(1):1254. PUBMED | CROSSREF
28. Wenham C. What we have learnt about the World Health Organization from the Ebola outbreak. *Philos Trans R Soc Lond B Biol Sci* 2017;372(1721):20160307. PUBMED | CROSSREF
29. Kiggundu R, Waswa JP, Konduri N, Kasujja H, Murungi M, Vudriko P, et al. A One Health approach to fight antimicrobial resistance in Uganda: Implementation experience, results, and lessons learned. *Biosaf Health* 2024;6(2):125-32. PUBMED | CROSSREF
30. Grolla A, Jones SM, Fernando L, Strong JE, Ströher U, Möller P, et al. The use of a mobile laboratory unit in support of patient management and epidemiological surveillance during the 2005 Marburg outbreak in Angola. *PLoS Negl Trop Dis* 2011;5(5):e1183. PUBMED | CROSSREF
31. Roddy P, Weatherill D, Jeffs B, Abaakouk Z, Dorion C, Rodriguez-Martinez J, et al. The Medecins Sans Frontieres intervention in the Marburg hemorrhagic fever epidemic, Uige, Angola, 2005. II. lessons learned in the community. *J Infect Dis* 2007;196 Suppl 2:S162-7. PUBMED | CROSSREF
32. Sharpe CH, Willems A, Robinson A, Fitzgerald T, Letts J, Dalton C, et al. Applying an after-action review process to examine a complex public health response in New South Wales (NSW), Australia: lessons for reflective practice. *Public Health Res Pract* 2025;35(2):PU24011. PUBMED | CROSSREF
33. World Health Organization (WHO). *Response to Marburg Virus Disease Outbreak in Tanzania - 2025*. Geneva, Switzerland: WHO; 2025.
34. Ministry of Health Republic of Rwanda. *After Action Review (AAR) of Marburg Virus Disease Outbreak Response in Rwanda*. Kigali, Rwanda: Ministry of Health Republic of Rwanda; 2025.

35. World Health Organization (WHO). Lessons from Marburg response to sharpen emergency response in Tanzania. https://www.afro.who.int/countries/united-republic-of-tanzania/news/lessons-marburg-response-sharpen-emergency-response-tanzania. Updated July 7, 2023. Accessed March 4, 2025.
36. World Health Organization (WHO). Disease outbreak news: Marburg virus disease - Ghana. https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON409. Updated September 26, 2022. Accessed March 4, 2025.
37. World Health Organization (WHO). *MARBURG RIPOSTE - Rapport sur les Interventions de l'OMS Guinée*. Geneva, Switzerland: WHO; 2021.