



Investing in preparedness for rapid detection and control of epidemics: analysis of health system reforms and their effect on 2021 Ebola virus disease epidemic response in Guinea

Mory Keita,^{1,2} Ambrose Talisuna ,¹ Dick Chamla,¹ Barbara Burmen,³ Mahamoud Sama Cherif,⁴ Jonathan A Polonsky ,^{5,6} Samuel Boland,⁷ Boubacar Barry,⁶ Samuel Mesfin,⁶ Fodé Amara Traoré,⁸ Jean Traoré,⁸ Jean Paul Kimenyi,¹ Amadou Bailo Diallo,¹ Togbemabou Primous Godjedo,¹ Tieble Traore,¹ Alexandre Delamou,⁹ Georges Alfred Ki-zerbo,¹⁰ Stephanie Dagon,² Olivia Keiser,² Abdou Salam Gueye¹

To cite: Keita M, Talisuna A, Chamla D, *et al.* Investing in preparedness for rapid detection and control of epidemics: analysis of health system reforms and their effect on 2021 Ebola virus disease epidemic response in Guinea. *BMJ Global Health* 2023;**8**:e010984. doi:10.1136/bmjgh-2022-010984

Handling editor Seye Abimbola

Received 16 October 2022
Accepted 21 December 2022



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to

Dr Mory Keita; mokeita@who.int

ABSTRACT

The 2014–2016 West Africa Ebola Virus Disease (EVD) Epidemic devastated Guinea's health system and constituted a public health emergency of international concern. Following the crisis, Guinea invested in the establishment of basic health system reforms and crucial legal instruments for strengthening national health security in line with the WHO's recommendations for ensuring better preparedness for (and, therefore, a response to) health emergencies. The investments included the scaling up of Integrated Disease Surveillance and Response; Joint External Evaluation of International Health Regulation capacities; National Action Plan for Health Security; Simulation Exercises; One Health platforms; creation of decentralised structures such as regional and prefectural Emergency Operation Centres; Risk assessment and hazard identification; Expanding human resources capacity; Early Warning Alert System and community preparedness. These investments were tested in the subsequent 2021 EVD outbreak and other epidemics. In this case, there was a timely declaration and response to the 2021 EVD epidemic, a lower-case burden and mortality rate, a shorter duration of the epidemic and a significant reduction in the cost of the response. Similarly, there was timely detection, response and containment of other epidemics including Lassa fever and Marburg virus disease. Findings suggest the utility of the preparedness activities for the early detection and efficient containment of outbreaks, which, therefore, underlines the need for all countries at risk of infectious disease epidemics to invest in similar reforms. Doing so promises to be not only cost-effective but also lifesaving.

INTRODUCTION

In recent decades, emerging infectious disease outbreaks have occurred at an

SUMMARY BOX

- ⇒ Infectious diseases with epidemic potential, in particular Ebola virus disease (EVD), have demonstrated in Guinea (2014–2016), that a single unidentified transmission chain in a susceptible area (ie, an area with a weak health system and absence of an Early Warning Alert System) can quickly escalate beyond straightforward containment.
- ⇒ The 2014–2016 West African EVD epidemic was a compelling reminder of the need to strengthen preparations in all countries worldwide for improved global health security.
- ⇒ After this 2014–2016 EVD epidemic, the Guinean government and partners invested in strengthening epidemic preparedness and response capacity, which contributed to rapidly detect and respond to several subsequent epidemics.
- ⇒ Health reforms and investment in outbreak preparedness implemented in Guinea after 2014–2016 EVD outbreak collectively served to the early detection of the 2021 EVD outbreak and its rapid control (shorten duration of response and prevent international spread).
- ⇒ Governance and technical autonomy of epidemic response structures are needed as well as building trust with the community for rapid control of epidemics.

increasing scale and frequency.¹ Along with the recent and ongoing COVID-19 pandemic, these outbreaks should be a wake-up call for all countries to invest in preparedness to avoid their health systems being overwhelmed during health crises.²

Such preparedness activities may seem out of reach especially where health systems

generally perform poorly like most African countries,³ which are also prone to epidemics. During the COVID-19 pandemic, low-income groups were more affected in terms of morbidity and mortality. Furthermore, gender inequalities and family violence also increased during lockdowns further impacting on women.⁴ Epidemics can also create or incur indirect economic losses such as work-force absenteeism, wages not earned, lower tax revenue, informal health costs (eg, for patient transport), negative impacts on human resources for health, losses in the agriculture sector, reduced tourism and travel, reduced trade and retail activity, environmental impacts and/or educational losses, all of which can serve to exacerbate existing inequalities, especially for marginalised populations.^{5,6}

One profound example of these consequences of global health inequalities is the 2014–2016 EVD epidemic in West Africa. The epidemic exposed major health system weaknesses including severe shortages of skilled health workers and a general lack of preparedness within the health system for the prevention, detection and containment of the outbreak at its source.^{7,8} Subsequently, the largest, longest and deadliest outbreak of EVD in human history occurred, causing 28 652 infections and resulting in 11 325 deaths across 10 countries with 99% of fatalities occurring in three neighbouring countries: Guinea, Sierra Leone and Liberia.⁹ The direct fiscal costs of the 2014 EVD epidemic were estimated to be around 6 billion USD, while the estimated economic burden ranged from 2.8 to 32.6 billion USD in lost gross domestic product.¹⁰

Investment in epidemic preparedness is crucial, because its cost is small compared with the unmitigated impact of a health emergency.¹ Adequate investment in epidemic preparedness capacities can help communities and countries avoid or at least minimise the impacts of outbreaks. However, as the results of this investment in preparedness are not immediate and visible (especially when successful),⁷ many governments inadequately invest in building preventative capacities and implementing preventive interventions during the ‘pre-outbreak’ period.¹¹

Nevertheless, building on lessons learnt from the West African EVD disaster, and in line with the Joint external evaluation (JEE) report of International Health Regulations, 2005 (IHR, 2005) core capacities,¹² Guinea invested in preparedness and health emergency management capacity after the 2014–2016 EVD epidemic.¹³ The country then was able to rapidly detect and respond to several epidemics from 2017 to 2020, including yellow fever, measles, anthrax, Lassa fever, food-borne illness, circulating vaccine-derived poliovirus type 2 (cVDPV2) and COVID-19.¹⁴ The country has also been stress testing its capacity to respond to several concurrent epidemics (yellow fever, COVID-19, EVD, Lassa fever and Marburg virus disease) from 2020 to 2021. This latest EVD outbreak declared on 14 February 2021 was reported in Nzerekore, near the epicentre of the previous outbreak¹⁵ and lasted only 5 months.

Based on field experience, as a result of participating in both EVD outbreaks as well as other outbreaks and preparedness capacity building activities, we described in this paper, health system reforms conducted in Guinea before, during and after the 2021 EVD outbreak that may have contributed to a more effective response and its rapid containment.

THE ‘PREOUTBREAK’ PERIOD (FROM THE END OF 2014–2016 EVD OUTBREAK LEADING UP TO THE 2021 EVD OUTBREAK)

The 2014–2016 EVD epidemic evidenced the need for the affected countries, and other low-income countries with similarly weak health systems, to build stronger health systems and surveillance mechanisms in order to prevent future outbreaks from escalating in a similar fashion.¹⁶ Accordingly, Guinea implemented WHO recommendations by maintaining 90 days of postepidemic enhanced surveillance, during which several capacity-building activities, such as Integrated Disease Surveillance and Response (IDSR) cascade trainings from national to community level and data management training for Health District Management Team, were carried out to strengthen the country’s capacities.¹⁷ Subsequently, the government achieved key preparedness activities related to IHR core capacities (discussed hereafter).

Scaling up IDSR capacity

Challenges in the transmission and management of surveillance data contributed to the delay in detecting and confirming the EVD outbreak.¹⁸ There was a shortage of IDSR-trained public health workers, leading to under-reporting of cases and problems with data completeness, accuracy and reliability.¹⁹ In 2015, the Guinean Ministry of Health (MoH) began IDSR strengthening^{19,20} to have surveillance and early warning systems that transmitted information from the community level to the health centre level, which was then sequentially relayed to the district level, the regional level and, finally, to the central or national level.

Joint External Evaluation

Guinea conducted its first JEE²¹ in April 2017 using the third version of the JEE that has 19 technical areas and 48 indicators.¹² The JEE helped determine the country’s baseline capacities as required under the IHR (2005). The country was found to have no capacity on 18 indicators, limited capacity on 20 indicators, developed capacity on nine indicators and demonstrated capacity on one indicator. The JEE informed the development of the National Action Plan for Health Security

National Action Plan for Health Security

Guinea’s national health security action plan²² was developed and validated in April 2019 due to extensive work that brought together 19 focal points of the IHR technical areas and partners. This 4-year plan (2019–2023) involved the sectors of health, livestock, environment and the Ministry of Agriculture.²³

Simulation exercises (SIMEX)

During the 2014–2016 EVD outbreak in West Africa, WHO and others within the public health community emphasised the need for simulation exercises to ensure that public health emergency response systems were in place to manage the importation of EVD into high-priority, non-affected countries.²⁴

In October 2018, the National Health Security Agency (ANSS) of Guinea, with the support of partners including WHO, organised tabletop exercises and drilled simulation exercises for the response to a possible cholera outbreak. These simulation exercises revealed that the preparedness and response mechanisms including Regional Epidemic Alert and Response Teams (ERARE), Prefectural Epidemic Alert and Response Teams (EPARE), Epidemic-prone diseases Treatment Centers (CT-Epi), Public Health Emergency Operations Centers (PHEOCs) are in place and capable of being operational at any time. Additionally, the strong involvement of the administrative and political authorities and the commitment of the communities in the localities visited revealed their interest in the emergency response teams.²⁵

One health

In the wake of the 2014–2016 EVD outbreak, Guinea was targeted for substantial support and capacity building from the USA and other nations to facilitate the recovery and renewal of its health system incorporating a One Health approach.^{26 27} In November 2016, an interministerial meeting held in Dakar, Senegal, resulted in formalised commitments from the three nations (Guinea, Liberia and Sierra Leone) to strengthen resilience to health threats by establishing a Regional Strategic Roadmap to institutionalise the One Health approach. Since then, Guinea has made significant progress towards establishing National One Health platforms to coordinate health security interventions in collaboration with international partners.²⁸

Creation of decentralised structures

Based on experiences in the 2014–2016 EVD epidemic in Guinea, the ANSS acquired decentralised structures for its operationalisation. They include 8 ERARE; 33 EPARE; 33 CT-Epi and 33 PHEOCs. Normative documents were developed to guide and assist the staff of these facilities.²⁵

Risk assessment and hazard identification

Guinea conducted a risk assessment in October 2017 to develop a multihazard plan as recommended by the JEE report.¹² The exercise involved a risk assessment and vulnerability mapping in the country, using the Strategic Tools for Assessing Risk and Vulnerability Risk Assessment and Mapping approach. Six hazards with a high risk of occurrence and impact on communities in Guinea, including EVD, were identified²⁹ and a multihazards plan developed.

Expanding human resource capacity

The state of the Guinean health workforce is one of the country's bottlenecks in advancing health outcomes. The 2014–2015 EVD outbreak provided a policy window to invest in the workforce and reform the health system.¹³ The Government of Guinea launched its Field Epidemiology Training Programme (FETP) in 2016. Since then, it has graduated 179 staff from the frontline (ie, district-level) programme and 16 from the intermediate programme and 10 advanced FETP graduates who participated in the Burkina Faso (Formerly West Africa) Field Epidemiology and Laboratory Training Programme.³⁰

Strengthening community preparedness

In the 2014–2016 post—Ebola agenda—setting for health system strengthening, the MoH Guinea recruited 5000 Healthcare Workers (HCW) and deployed in rural areas. A number of health centres were rehabilitated and logistics support provided to health districts for field activities, such as vaccination campaigns and training, and local contracting of 10–15 community health workers per subdistrict for epidemic-prone diseases surveillance.³¹

THE OUTBREAK PERIOD (14 FEBRUARY 2021 TO 19 JUNE 2021)

On the 14 February 2021, a case of EVD was identified in N'zerekore. Thereafter, reactive interventions—including establishing an Emergency Operations Centre (EOC); the reinforcement of an Early Warning Alert System (EWAR); and the reinforcement of active readiness capabilities in districts adjacent to N'zerekore were set up to contain the 2021 EVD outbreak.

Emergency operation centres

Once EVD was detected, it was crucial to have a well-prepared workforce (sufficient in both skills and numbers); updated response plan; standard operating procedures (SOPs) and protocols for field epidemiology and laboratory investigations, case identification, management, and contact tracing protocols. These SOPs and protocols were implemented through functional EOC that provided leadership with clear lines of command and with daily review of the outbreak.⁷ EOC activation procedures and outbreak management were coordinated mainly at district and regional (Nzerekore) in 2021.

Early Warning Alert System

EWAR³² help in: detecting the first case of the disease in a population previously free of disease; detecting new cases in an area already affected by disease; detecting of an abnormal increase in the level of a disease normally present from a baseline level in a timely fashion; screening for individual cases of a non-communicable disease; and first detecting an invasive species in an area previously free of that species.³³

In Guinea, the WHO supported the strengthening of the alert system.³⁴ A green number (a toll-free telephone line) was set up over the outbreak period that community

members could call to alert the health system of any health event in the community, including but not limited to EVD-related concerns.

Active readiness in non-affected health districts

Based on the conclusion of the WHO rapid risk assessment (a very high risk at the national level, an increased risk at the regional level, and a low risk at the global level); and considering lessons learnt from prior EVD experiences (including the need to move fast and use national expertise much as possible), dedicated full response capacity was rapidly established in N’zerekore—the areas of active transmission. Additionally, an active response mode in the six health districts bordering N’zerekore was also developed and implemented, due to their proximity to known cases. Scaling up active readiness in other health districts and regions also occurred through reinforcing the existing IDSR mechanism with daily alerts and reporting.

THE 2021 EVD POST-OUTBREAK 90 DAY’S SURVEILLANCE PERIOD

The ANSS and the WHO maintained enhanced vigilance in the region until the end of the 90 days following the declaration of the end of the EVD epidemic in Guinea. Additionally, as part of the monitoring and evaluation of ‘HR’s capacities, the Guinean MoH with technical support of WHO conducted the After-Action Review

of three outbreaks (EVD in Nzerekore, Marburg virus disease in Gueckedou and Yellow Fever in Koundara) in December 2021.³⁵ Lessons learnt and best practices identified during this exercise will help to improve the country preparedness for better response to future outbreaks.

WAS GUINEA BETTER PREPARED FOR THE 2021 EVD OUTBREAK?

Timely outbreak response

The 2014–2016 West Africa EVD outbreak went on unobserved for over 3 months³⁶; the outbreak that began in December 2013 was not officially declared until 23 March 2014 despite the first alert being issued on 24 January 2014. Further, the declaration of a Public Health Issue of International Concern (PHEIC), which would motivate financial and logistic support to the countries most affected and elevated the emergency to one demanding global attention, was not declared until 8 August 2014.³⁷ On 7 March 2015, the WHO (in collaboration with MERCK) availed the only advanced experimental vaccine, a full year after the epidemic’s onset, as part of a clinical trial.³⁸ The Report of the EVD Interim Assessment Panel commissioned by the WHO stated that there were “significant and unjustifiable delays occurred in the declaration” in relation to the delay between the WHO being informed of the 2014–2016 EVD epidemic in West Africa and declaring it a PHEIC.³⁹

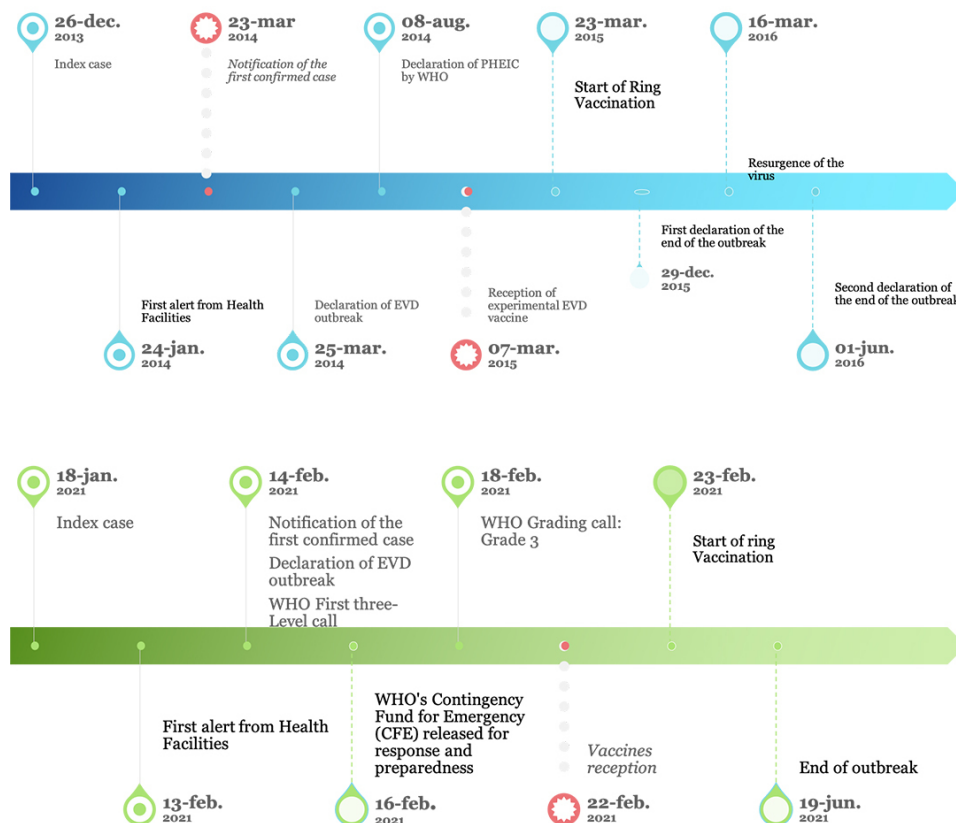


Figure 1 Timelines of the major events during the 2014–2016 (blue) and 2021 (green) EVD outbreaks in Guinea. EVD, Ebola Virus Disease; PHEIC, Public Health Issue of International Concern.

Table 1 Summary of the Case Fatality Rate (CFR) for the first and second EVD outbreaks in Guinea

EVD cases	Year of outbreak					
	2014–2016			2021		
	Number of cases	Number of deaths	Case fatality rate (CFR)	Number of cases	Number of deaths	Case fatality rate (CFR)
Confirmed cases	3358	2088	62%*	16	5	31%*
Probable cases	456	456	–	7	7	–
Total number	3814	2544	67%†	23	12	52%†

*CFR among confirmed EVD cases.
 †Global CFR.
 CFR, Case Fatality Rate; EVD, Ebola Virus Disease.

During the 2021 EVD outbreak, the national health authorities and the WHO rapidly reacted on notification of the suspected epidemic.⁴⁰ The outbreak that commenced on 15 January 2021 (the date of symptoms onset of the first case) was reported as an alert on 28 January 2021, after a cluster of deaths in the sub-prefecture of Gouécké, N’zerekore Region. The official outbreak declaration was made on 14 February 2021, that is, within 2 weeks after alert reporting and at the same day the WHO activated its emergency procedures to support the response⁴¹ (figure 1).

Following the declaration, a swift outbreak response was enacted with the deployment of a national support team from ANSS rapidly to thoroughly conduct an investigation of the confirmed cases and roll out specific tools for rapid epidemic control.⁴⁰ With the support of WHO, the government availed vaccines that were already in existence on 23 February 2021, that is, within 1 week of the outbreak declaration. The two new Food and Drug Administration-approved therapeutic drugs (Mab-114 and Regeneron) for EVD were availed to treat eight of the confirmed EVD cases, all of whom survived.

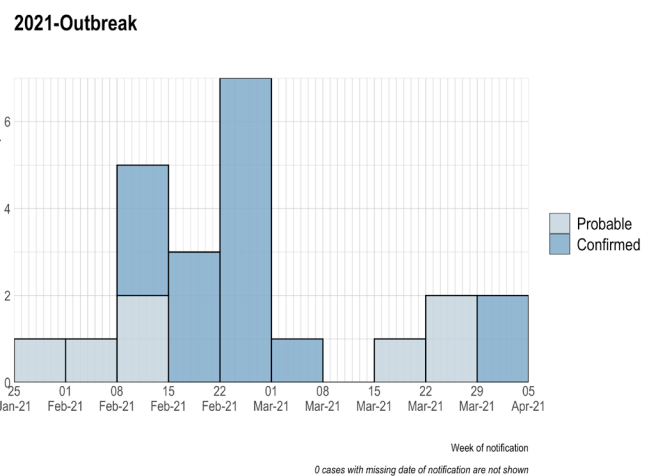
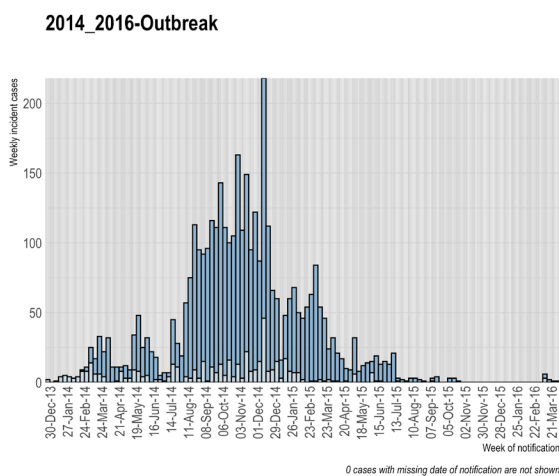
The country opened an isolation centre within 48 hours of the declaration of the outbreak, compared with the 3 weeks it took following declaration of the 2014–2016 West Africa EVD epidemic.⁴²

Efficient contact tracing and case investigations

The newly trained FETP graduates played leading roles in response to the 2021 EVD outbreak in the south-eastern part of the country, including alert validation, case investigations, active case finding, contact tracing, and data management. Their contributions as well as those of the community workers in local one-health platforms, led to the successful follow-up of >95% of EVD contacts, an essential component of successful EVD response.³⁰ The one-health platforms contributed to the investigation of the source of the outbreak that is reportedly to be a persistent virus linked to the 2014–2016 EVD outbreak but not a new spillover from animal to humans.¹⁵

A reduction in the case fatality rate

The disease incidence and lethality was reduced.⁴⁰ The overall lethality decreased from 2544/3814 (67%) in


Figure 2 Comparison of the epidemiological curves of the two EVD outbreaks 2014–2016 and 2021 in Guinea. EVD, Ebola Virus Disease.

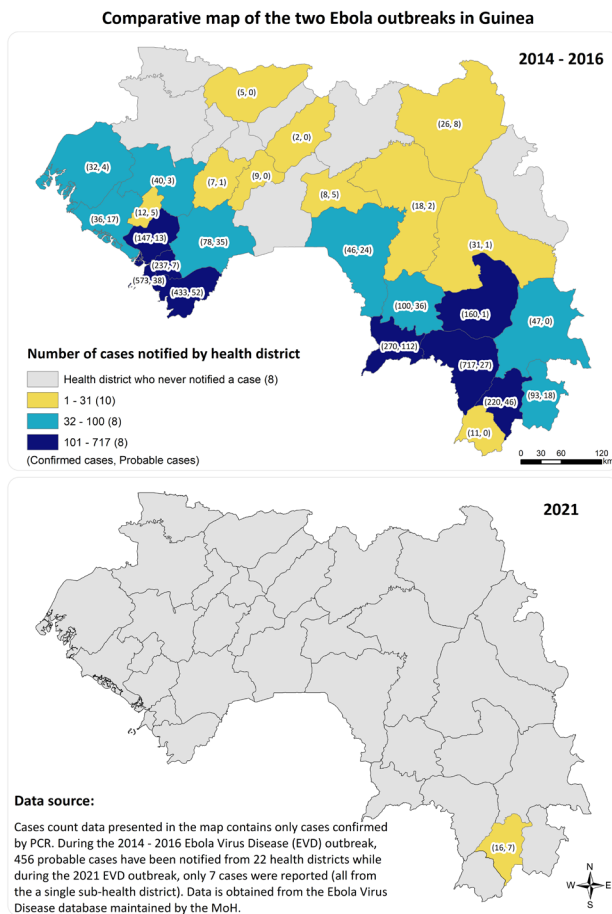


Figure 3 Comparison of the spread of the two EVD outbreaks 2014–2016 and 2021 in Guinea. EVD, Ebola Virus Disease; MoH, Ministry of Health.

the 2014–2016 epidemic, to 12/23 (52%) in the 2021 outbreak, while the lethality of confirmed cases was reduced from 62% in 2014–2016 to just 31% in 2021. While this may be due to more readily accessible vaccination and therapeutic interventions, the rapid availability of these interventions nevertheless rested on the preparedness activities undertaken in Guinea before the 2021 outbreak (table 1).

Shorter duration of the outbreak

The 2014–2016 West Africa EVD epidemic was controlled after more than 2 years, while the 2021 epidemic only lasted 5 months (figure 2). While the first one cost billions of dollars,¹⁰ the second one cost around 45 million.⁴³

Rapid control of the spread of the outbreak

While the initial outbreak spread over to 30 out of 38 Health Districts in the country, the subsequent outbreak was contained within one health district (figure 3).

Early detection of other epidemics

The extension of EVD surveillance into neighbouring districts identified a unique case of Lassa Fever and SARS-CoV-2 coinfection in a patient from Yomou prefecture in southeast Guinea on 6 May 2021. An alert was raised

regarding the individual whose signs and symptoms of illness were commensurate with EVD infection followed prompt declaration of a Lassa fever epidemic and the rapid implementation of control measures to limit the virus’ spread in Guinea.⁴⁴

In addition, a Marburg virus disease (MVD) outbreak was confirmed in Gueckedou on 9 August 2021. This is the first time it has been detected in Guinea and West Africa. An improved preparedness confined this case to a single confirmed case.⁴⁵

WHAT WAS THE OVERALL EFFECT OF HEALTH REFORMS ON EPIDEMICS DETECTION AND RESPONSE?

Admittedly, Guinea seemed better prepared for the 2021 epidemic than in 2014–2016. While the impact of enhanced preparedness and response activities contributed to the early detection of and response to other epidemics such as yellow fever, measles, anthrax, Lassa fever, food-borne illness, cVDPV2,¹⁴ the institutional reforms undertaken had mixed effects on the COVID-19 response.^{46 47} Guinea delayed in declaring and taking strong action for political reasons, as 2020 was an election year. The president of the independent national electoral commission was one of the early and most visible victims.⁴⁸

Furthermore, trust between political authorities and communities is never guaranteed. For instance, the community deaths reported in the village of Kpaghalaye during the 2021 epidemic,⁴⁹ which resulted in the latest confirmed case preferring to remain hidden in the community until he recovered as opposed to accepting admission to the treatment centre.

Thus, governance and technical autonomy of epidemic response structures as well as building trust with the community are needed in addition to health sector reforms to improve emergency preparedness.

CONCLUSION

While specifically appraising the epidemiological consequences of any one intervention is not possible, the overall effect may indicate such activities represent important preparedness and early warning investments that all countries at risk of epidemics should consider. The WHO Regional Office for Africa’s (AFRO’s) three flagship projects which incorporate lessons learned from COVID-19, EVD, and other health emergencies is a viable model for Member States to develop their capacities to prepare for, detect and respond to public health emergencies.⁵⁰

Author affiliations

- ¹Emergency Preparedness and Response, World Health Organization Regional Office for Africa, Brazzaville, Republic of Congo
- ²Institute of Global Health, Faculty of Medicine, University of Geneva, Geneva, Switzerland
- ³Health Security Preparedness, World Health Organization, Geneva, Switzerland
- ⁴Faculty of Sciences and Health Technics, Gamal Abdel Nasser University of Conakry, Conakry, Guinea

⁵Geneva Centre of Humanitarian Studies, Faculty of Medicine, University of Geneva, Geneva, Switzerland

⁶Emergency Response, World Health Organization, Geneva, Switzerland

⁷Department of Global Health and Development, London School of Hygiene and Tropical Medicine, London, UK

⁸National Agency for Health Security, Ministry of Health, Conakry, Guinea

⁹African Centre of Excellence for the Prevention and Control of Communicable Diseases, Gamal Abdel Nasser University of Conakry, Conakry, Guinea

¹⁰Office at the African Union (AU) and Un Economic Commission for Africa (UNECA), World Health Organization Regional Office for Africa, Brazzaville, Republic of Congo

Twitter Mory Keita @morykeita1980, Jonathan A Polonsky @jonny_polonsky and Togbemabou Primous Godjedo @godjedoprimous

Contributors MK conceptualised the manuscript and wrote the first draft. All authors contributed to the conceptualisation of the manuscript, and revised and critically reviewed drafts. MK and BB edited the final draft. All authors approved the final draft for submission.

Funding O.Keiser was supported by the Swiss National Science Foundation (Grant number PP00P3_202660)

Map disclaimer The inclusion of any map (including the depiction of any boundaries therein), or of any geographic or locational reference, does not imply the expression of any opinion whatsoever on the part of BMJ concerning the legal status of any country, territory, jurisdiction or area or of its authorities. Any such expression remains solely that of the relevant source and is not endorsed by BMJ. Maps are provided without any warranty of any kind, either express or implied.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon request.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Ambrose Talisuna <http://orcid.org/0000-0001-6436-3415>

Jonathan A Polonsky <http://orcid.org/0000-0002-8634-4255>

REFERENCES

- Lee VJ, Ho M, Kai CW, *et al*. Epidemic preparedness in urban settings: new challenges and opportunities. *Lancet Infect Dis* 2020;20:527–9.
- Sweileh WM. Global research activity on health system preparedness against viral infectious disease outbreaks. *Disaster Med Public Health Prep* 2022;16:1–7.
- Jamison DT, Gelband H, Horton S. Front Matter. In: Jamison DT, Gelband H, Horton S, eds. *Disease Control Priorities, Third Edition (Volume 9): Improving Health and Reducing Poverty*. Disease Control Priorities. The World Bank, 2017: i–xviii.
- Green H, Fernandez R, MacPhail C. The social determinants of health and health outcomes among adults during the COVID-19 pandemic: a systematic review. *Public Health Nurs* 2021;38:942–52.
- Bloom DE, Cadarette D, Sevilla JP. *Epidemics and economics*. *Finance Dev*. 55, 2018.
- Lung F. *Rapid literature review: disaster risk financing and public finance Maint COVID-19*, 2020.
- Nzietchueng S, Kamarage D, Rwego IB, *et al*. Post-Ebola awakening: urgent call for investing in maintaining effective preparedness capacities at the National and regional levels in sub-Saharan Africa. *East Afr Health Res J* 2019;3:79–84.
- Buseh AG, Stevens PE, Bromberg M, *et al*. The Ebola epidemic in West Africa: challenges, opportunities, and policy priority areas. *Nurs Outlook* 2015;63:30–40.
- Ohimain EI, Silas-Olu D. The 2013–2016 Ebola virus disease outbreak in West Africa. *Curr Opin Pharmacol* 2021;60:360–5.
- Huber C, Finelli L, Stevens W. The economic and social burden of the 2014 Ebola outbreak in West Africa. *J Infect Dis* 2018;218:S698–704.
- Clarke L, Patouillard E, Mirelman AJ, *et al*. The costs of improving health emergency preparedness: a systematic review and analysis of multi-country studies. *EClinicalMedicine* 2022;44:101269.
- Santé O mondiale de la. Évaluation externe conjointe des principales capacités RSI de la République de Guinée : rapport de mission : 23-28 avril 2017. Organisation mondiale de la Santé. Available: <https://apps.who.int/iris/handle/10665/258726>
- van de Pas R, Kolie D, Delamou A, *et al*. Health workforce development and retention in guinea: a policy analysis post-Ebola. *Hum Resour Health* 2019;17:63.
- Williams GS, Impouma B, Mboussou F, *et al*. Implementing epidemic intelligence in the who African region for early detection and response to acute public health events. *Epidemiol Infect* 2021;149:e261.
- Keita AK, Koundouno FR, Faye M, *et al*. Resurgence of Ebola virus in 2021 in guinea suggests a new paradigm for outbreaks. *Nature* 2021;597:539–43.
- Perry HB, Dhillon RS, Liu A, *et al*. Community health worker programmes after the 2013–2016 Ebola outbreak. *Bull World Health Organ* 2016;94:551–3.
- Coltart CEM, Lindsey B, Ghinai I, *et al*. The Ebola outbreak, 2013–2016: old lessons for new epidemics. *Philos Trans R Soc Lond B Biol Sci* 2017;372:20160297.
- Reynolds E, Diallo B, Macdonald P. Implementation of an electronic disease surveillance system in guinea, 2016–2018. *Online J Public Health Inform* 2019;11:e363.
- Hemingway-Foday J, Souare O, Reynolds E, *et al*. Improving integrated disease surveillance and response capacity in guinea, 2015–2018. *Online J Public Health Inform* 2019;11:e364.
- Guinée M de la S-R de. Plan de Renforcement de la surveillance des maladies Potentiel Epidémique en Guinée (2015-2017). Available: <https://portail.sante.gov.gn/document/plan-de-renforcement-de-la-surveillance-des-maladies-a-potentiel-epidémique-2015-2017-ms11-2015/> [Accessed 19 May 2022].
- Organization WH. *Joint external evaluation tool: international health regulations (2005)*. 2018Published online.
- WHO. *NAPHS for All: A Country Implementation Guide for National Action Plan for Health Security (NAPHS)*. World Health Organization, 2019.
- Sanitaire AN de S. *Plan d'Action Nationale de Sécurité Sanitaire*, 2019.
- WHO. *WHO Simulation Exercise Manual: A Practical Guide and Tool for Planning, Conducting and Evaluating Simulation Exercises for Outbreaks and Public Health Emergency Preparedness and Response*. World Health Organization, 2017.
- World Health Organization. Préparation et riposte aux épidémies : Des exercices de simulations pour évaluer le dispositif contre une éventuelle flambée de choléra. Available: <https://www.afro.who.int/node/10511> [Accessed 20 May 2022].
- Organization WH. *Taking a Multisectoral One Health Approach: A Tripartite Guide to Addressing Zoonotic Diseases in Countries*. Food & Agriculture Org, 2019.
- Standley CJ, Carlin EP, Sorrell EM, *et al*. Assessing health systems in guinea for prevention and control of priority zoonotic diseases: a one health approach. *One Health* 2019;7:100093.
- Agbo S, Gbaguidi L, Biliyar C, *et al*. Establishing national Multisectoral coordination and collaboration mechanisms to prevent, detect, and respond to public health threats in guinea, Liberia, and Sierra Leone 2016–2018. *One Health Outlook* 2019;1:4.
- World Health Organization. *Cartographie Des Risques d'urgences Sanitaires République de Guinée Rapport Technique*, 2017.
- Martin R, Fall IS. Field epidemiology training programs to accelerate public health workforce development and global health security. *Int J Infect Dis* 2021;110 Suppl 1:S3–5.
- Kolie D, Delamou A, van de Pas R, *et al*. 'Never let a crisis go to waste': post-Ebola agenda-setting for health system strengthening in guinea. *BMJ Glob Health* 2019;4:e001925.
- Schenkel K, Kannagarage NW, Haskew C. Early Warning, Alert and Response (EWAR): a key area for countries in preparedness and response to health emergencies/Alerte precoce et reponse (EWAR): une composante cle de la preparation et de la reponse des pays face aux urgences sanitaires. *Wkly Epidemiol Rec* 2018;93:269–74 <https://apps.who.int/iris/bitstream/handle/10665/272601/WER9320.pdf>
- Cameron AR, Meyer A, Faverjon C, *et al*. Quantification of the sensitivity of early detection surveillance. *Transbound Emerg Dis* 2020;67:2532–43.

- 34 Keita M, Lucaccioni H, Ilumbulumbu MK, *et al.* Evaluation of early warning, alert and response system for Ebola virus disease, Democratic Republic of the Congo, 2018-2020. *Emerg Infect Dis* 2021;27:2988-98.
- 35 Sanitaire AN de S. *Revue Après Action de La Préparation et de La Riposte Contre Les Fièvres Hémorragiques Virales En Guinée : Fièvre Jaune, Maladie Virus Ébola et Maladie Virus Marburg*, 2021.
- 36 Perkins MD, Dye C, Balasegaram M, *et al.* Diagnostic preparedness for infectious disease outbreaks. *Lancet* 2017;390:2211-4.
- 37 Siedner MJ, Kraemer J. The global response to the Ebola fever epidemic: what took so long? PLOS Med blog, 2014. Available: <https://speakingofmedicine.plos.org/2014/08/22/global-response-ebola-fever-epidemic-took-long/> [Accessed 28 Dec 2022].
- 38 Henao-Restrepo AM, Longini IM, Egger M, *et al.* Efficacy and effectiveness of an rVSV-vectored vaccine expressing Ebola surface glycoprotein: interim results from the guinea ring vaccination cluster-randomised trial. *Lancet* 2015;386:857-66.
- 39 Eccleston-Turner M, McArdle SEccleston-Turner M, Brassington I, eds. *The Law of Responsibility and the World Health Organisation: A Case Study on the West African Ebola Outbreak BT - Infectious Diseases in the New Millennium: Legal and Ethical Challenges*. Springer international publishing, 2020: 89-109.
- 40 Delamou A, Keita M, Beavogui AH, *et al.* Is guinea meeting the challenges to control the new Ebola virus disease outbreak in West Africa? *Prev Med Rep* 2021;23:101394.
- 41 WHO. *Emergency response framework ERF*, 2017.
- 42 Programme WF. Building an Ebola treatment centre in guinea, 2014. Available: <https://reliefweb.int/report/guinea/building-ebola-treatment-centre-guinea> [Accessed 25 May 2022].
- 43 Guinée M de la S-R de. *Plan de Réponse La Maladie virus Ebola en Guinée*, 2021.
- 44 Keita M, Cherif MS, Sivahera B, *et al.* Case report: COVID-19 and Lassa fever coinfection in an Ebola suspected patient in guinea. *Am J Trop Med Hyg* 2022;106:1094-7.
- 45 Okonji OC, Okonji EF, Mohanan P, *et al.* Marburg virus disease outbreak amidst COVID-19 in the Republic of guinea: a point of contention for the fragile health system? *Clin Epidemiol Glob Health* 2022;13:100920.
- 46 Delamou A, Sidibé S, Camara A, *et al.* Tackling the COVID-19 pandemic in West Africa: have we learned from Ebola in guinea? *Prev Med Rep* 2020;20:101206.
- 47 Millimouno TM, Ahmed MAA, Ly BA, *et al.* Evolution of the COVID-19 pandemic over six weeks in four French-speaking countries in West Africa. *J Glob Health* 2021;11:03008.
- 48 Falisse J-B, Macdonald R, Molony T, *et al.* Why have so many African leaders died of COVID-19? *BMJ Glob Health* 2021;6:e005587.
- 49 Kolie D, Van De Pas R, Fofana TO, *et al.* Guinea's response to syndemic hotspots. *BMJ Glob Health* 2021;6:e006550.
- 50 World Health Organization. Ensuring health security in the African region, 2021. Available: <https://www.afro.who.int/publications/ensuring-health-security-african-region> [Accessed 20 May 2022].