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Rapid assessment of local disease control measures against the Marburg virus outbreak in Ethiopia in late 2025

Qingcui Wu [a,1], Zihao Guo [b,1], Zihan Yuan [a,1], Sheikh Taslim Ali [c], Kai Wang [d], Sukhyun Ryu [e], Lirong Cao [b], Shengzhi Sun [f], Marc K.C. Chong [b,g], Salihu S. Musa [h], Daihai He [i], Shi Zhao [a,*], Zijian Feng [j,2], Abdulrazaq G. Habib [k,2], Yuantao Hao [l,m,n,2]

[a] School of Public Health, Tianjin Medical University, Tianjin, China
[b] JC School of Public Health and Primary Care, Chinese University of Hong Kong, Hong Kong, China
[c] School of Public Health, University of Hong Kong, Hong Kong, China
[d] Department of Medical Engineering and Technology, Xinjiang Medical University, Urumqi, China
[e] Department of Preventive Medicine, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea
[f] School of Public Health, Capital Medical University, Beijing, China
[g] CUHK Shenzhen Research Institute, Shenzhen, China
[h] Department of Mathematics, Institute for Health Computing, University of Maryland, North Bethesda, MD, USA
[i] Department of Applied Mathematics, Hong Kong Polytechnic University, Hong Kong, China
[j] School of Public Health and Emergency Management, Southern University of Science and Technology, Shenzhen, China
[k] Department of Medicine, Bayero University, Kano, Nigeria
[l] Peking University Center for Public Health and Epidemic Preparedness and Response, Peking University, Beijing, China
[m] School of Public Health, Peking University, Beijing, China
[n] MoE Key Laboratory of Epidemiology of Major Diseases, Peking University, Beijing, China

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ABSTRACT

In November 2025, Marburg virus caused the first outbreak of Marburg virus disease (MVD) in Ethiopia. By December 15, a total of 14 laboratory-confirmed cases were reported, including 9 deaths, corresponding to a case fatality ratio of 64.3% among confirmed cases. In the absence of licenced vaccines or antivirals, non-pharmaceutical interventions (NPIs) were implemented to control transmission. We developed a stochastic epidemic model incorporating a stochastic exponential growth process with reporting adjustment to assess the effectiveness of NPIs. The reporting ratio was modelled using a beta distribution, and transmission parameters were estimated via Markov chain Monte Carlo with particle filtering for likelihood calculation. Using pre-NPI data (November 12-23), we estimated an exponential growth rate of 0.012 (95% credible interval [CrI]: 0.008, 0.014) per day, corresponding to an initial reproduction number of 1.13 (95% CrI: 1.09, 1.16). We projected 64 cases (95% CrI: 19, 189) and 41 deaths (95% CrI: 12, 122) during post-NPI period (November 24 to December 15) without interventions. Compared with 4 observed cases, NPIs were associated with an estimated effectiveness of 93.7% (95% CrI: 78.9, 97.9). These findings indicated moderate transmissibility of MVD,

* Corresponding author.
E-mail addresses: wuqingcuioo@163.com (Q. Wu), zihaoguo@cuhk.edu.hk (Z. Guo), 598939693@qq.com (Z. Yuan), alist15@hku.hk (S.T. Ali), wangkaimath@sina.com (K. Wang), gentryu@onehealth.or.kr (S. Ryu), lrcao@outlook.com (L. Cao), shengzhisun@ccmu.edu.cn (S. Sun), marc@cuhk.edu.hk (M.K.C. Chong), salihu-sabiu.musa@connect.polyu.hk (S.S. Musa), daihai.he@polyu.edu.hk (D. He), zhaoshi.cmsa@gmail.com (S. Zhao), fengzj@sustech.edu.cn (Z. Feng), abdulrazaq_habib@yahoo.co.uk (A.G. Habib), haoyt@bjmu.edu.cn (Y. Hao).

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[1] QW, ZG, and ZY contributed equally to this work, and thus they were joint-first authors.
[2] ZF, AGH, and YH were joint-senior authors.

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and a potential transmission risk reduction following the implementation of control measures, underscoring the importance of timely intervention and sustained surveillance regarding local MVD activities.

1. Introduction

Marburg virus (MARV), a filovirus closely related to the Ebola virus, is a causative agent of Marburg virus disease (MVD), which is a severe zoonotic haemorrhagic fever characterized by multiorgan dysfunction, coagulation abnormalities, and high fatality rates ranging from 24% to 88% (Francis et al., 2025; World Health Organization, 2025). Owing to its high virulence in humans, MARV has been classified as a Category A Priority Pathogen by the National Institute of Allergy and Infectious Diseases of the United States (Bente et al., 2009). *Rousettus aegyptiacus* (i.e., Egyptian fruit bat) is considered the natural reservoir host of MARV, and zoonotic transmission to humans primarily occurs through exposure to infected bats or contaminated environments (Kajihara et al., 2019). Subsequent human-to-human transmission can occur through direct contact with bodily fluids of infected individuals or contaminated materials (World Health Organization, 2025). Since its first identification in 1967, sporadic outbreaks and imported cases of MVD have been reported in several African countries, posing persistent public health challenges, particularly in resource-limited settings where rapid outbreak containment remains difficult (Sibomana et al., 2025; Sidik, 2024). Currently, no licenced vaccines or specific antiviral treatments are available for MVD, and non-pharmaceutical interventions (NPIs), including case management, contact tracing, infection control, and related public health measures, remain essential for preventing further transmission (Harris, 2023).

On November 12, 2025, Ethiopia reported a suspected MVD case in Jinka town, which was subsequently confirmed with MARV infection on November 14, marking the first MVD outbreak in national history. As of December 15, a total of 14 laboratory-confirmed cases were reported, including 9 deaths (case fatality ratio, CFR of 64.3%), and an additional 5 probable cases who were all died. On January 26, 2026, the MVD outbreak was declared to end after 2 consecutive incubation periods (i.e., 42 days) since the last MVD case died (World Health Organization, 2026). During the outbreak, NPIs were the primary measures implemented against the MVD transmission. In this study, we assessed the effectiveness of local NPIs based on publicly available surveillance data.

2. Methods

We employed an epidemic model to capture the transmission process of MVD, using a classic exponential growth process with case reporting adjustment. Given that on November 21, there were 3 deaths (from laboratory-confirmed cases) out of 6 deaths reported from both probable and confirmed cases, the case reporting ratio (ρ) was set as a random variable following a beta distribution with a mean of 50% (close to 60% as previously reported in serosurvey) (Borchert et al., 2006), and a shape of 3.5, which accounted for the imperfect case reporting during the outbreak. The initial reported case number was $O_0 = 1$ on November 14 (i.e., the index day for $i = 0$), and thus the initial actual case number (C_0) followed a negative binomial distribution with a size of O_0 and a probability of ρ. Then, the actual case number on the $(i + 1)$-th day was modelled stochastically as a Poisson process $C_{i+1} \sim \text{Poi}(\lambda_{i+1})$ to account for the systematic noise generated from the model, where λ_{i+1} was modelled as a discrete-time exponential growth process $\lambda_{i+1} = C_i \cdot \exp(r \cdot \Delta t)$ and $\Delta t = 1$ day. To link the real-world observation (i.e., O) to model outcome (i.e., C), we constructed the likelihood function by assuming the reported case numbers followed a binomial random process, such that $O_i \sim \text{Bin}(\text{size} = C_i, \text{prob} = \rho)$, which accounted for the measurement noise of observations.

Local NPIs were triggered on November 12 but became effective against MVD transmission on November 23, which corresponded to 1 transmission generation (i.e., a mean serial interval of 11 days) after NPIs' implementation. Thus, the data between November 12 and 23 (i.e., pre-NPI period) were used for model fitting and parameter estimation. The best-fit model would then be used to simulate the MVD outbreak from November 24 to December 15 (i.e., post-NPI period) under a counterfactual scenario with no effect of local NPIs, and then compared with the data from November 24 and onwards to quantify the control effectiveness. Likelihood-based statistical inference was conducted by using a Markov chain Monte Carlo (MCMC) algorithm, and likelihood was calculated using a sequential Monte Carlo (i.e., particle filtering) approach (Ionides et al., 2006).

3. Results and discussion

We estimated that before November 24 (i.e., pre-NPI period), the exponential growth rate was 0.012 (95% credible interval [CrI]: 0.008, 0.014) per day (see Fig. 1A). Thus, during the initial MVD outbreak (i.e., pre-NPI period), the initial reproduction number was calculated at 1.13 (95% CrI: 1.09, 1.16) using the Euler-Lotka equation (Wallinga & Lipsitch, 2007), and the MVD's serial interval distribution for human-to-human transmission (Guo et al., 2023), which was largely consistent with previous

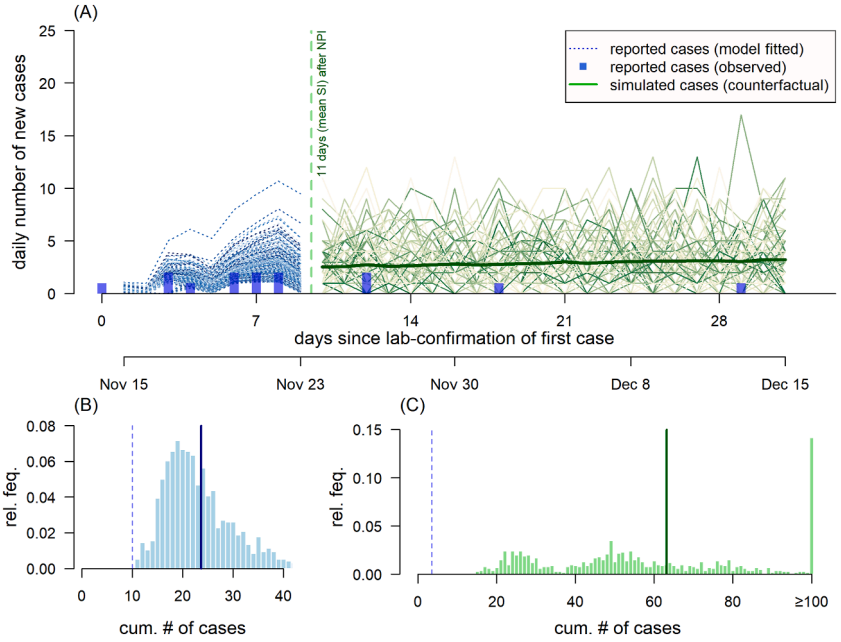

Fig. 1. Marburg virus disease (MVD) outbreak and the time point when local non-pharmaceutical interventions (NPIs) became effective in Ethiopia in late 2025. Panel (A) showed the reported and model-simulated epidemic curves of MVD cases. Blue bars represented the daily number of new MVD cases reported (i.e., O_i) based on calendar date of laboratory confirmation, which fitted the model-generated reported case number (i.e., blue dashed curves for 1000 runs of simulation). The best-fit model was simulated stochastically to generate counterfactual epidemic trajectories for post-NPI period (i.e., green curves), which were used to compare with the reported case numbers (i.e., blue bars) to further quantify the risk reduction of NPIs. The vertical green dashed line indicates November 23, 2025 (i.e., 1 mean serial interval after NPIs implementation), after which local NPIs against the MVD outbreak became effective. Panel (B) showed the cumulative number of reported (vertical blue dashed line, 10 cases in total) and fitted MVD cases (distribution and vertical blue bold line for mean value) during pre-NPI period (from November 14 to 23). Panel (C) showed the cumulative number of reported (vertical blue dashed line, 4 cases in total) and model-simulated MVD cases (distribution and vertical green bold line for mean value) under the counterfactual "without NPIs" scenario during post-NPI period (from November 24 to December 15).
Note: In panel (A), the model-fitted blue curves for pre-NPI period were shown as the reported case number (i.e., adjusted for the reporting ratio ρ), which was intended to assist the match between reported case number observations (blue bars) and fitting results (blue curves). All other model outputs in this figure were the MVD cases that occurred during epidemics (i.e., reported and unreported, C_i).

estimates ranging from 0.9 to 1.5 (Cuomo-et al., 2024). We found that during pre-NPI period, there were 24 cases (95% CrI: 13, 52, rounding to closest integer) occurred, of which only 10 were confirmed and reported eventually.

We simulated outbreak trajectories stochastically for post-NPI period using the best-fit epidemic model trained by pre-NPI data (see Fig. 1A). We estimated that in the absence of local NPIs, there would have been 64 cases (95% CrI: 19, 189) from November 24 to December 15 (see Fig. 1C), corresponding to a death toll of 41 (95% CrI: 12, 122). Thus, compared with 4 cases reported during post-NPI period, the effectiveness of NPIs was calculated at 93.7% (95% CrI: 78.9, 97.9), indicating a significant risk reduction following the implementation of control measures against the local MVD outbreak.

This study has several limitations. First, the serial interval distribution was obtained from previous studies due to the lack of detailed transmission pair data from the current outbreak. Second, the simulation of epidemic curves was based on a small number of seed cases observed and a simplified modeling framework that did not account for transmission heterogeneity. Therefore, the findings should be interpreted with cautions. Future modeling studies incorporating individual-based epidemiological data may provide more certain assessments of MVD transmission risks and effectiveness of outbreak control measures.

Our findings suggested a relatively low but significant transmission risk of MVD in Ethiopia, and timely NPIs may have contributed to reducing cases and deaths during the outbreak period. We highlighted the critical role of continuous disease surveillance and risk assessment, timely interventions, and public health preparedness in preventing and mitigating MVD outbreaks at community level.

CRediT authorship contribution statement

Qingcui Wu: Writing – original draft, Formal analysis, Data curation. **Zihao Guo:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Zihan Yuan:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Sheikh Taslim Ali:** Writing – review & editing. **Kai Wang:** Writing – review & editing. **Sukhyun Ryu:** Writing – review & editing. **Lirong Cao:** Writing – review & editing. **Shengzhi Sun:** Writing – review & editing. **Marc K.C. Chong:**

Writing – review & editing. **Salihu S. Musa:** Writing – review & editing. **Daihai He:** Writing – review & editing. **Shi Zhao:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Zijian Feng:** Writing – review & editing. **Abdulrazaq G. Habib:** Writing – review & editing. **Yuantao Hao:** Writing – review & editing.

Ethics approval and consent to participate

The data used in this study were secondary data and publicly available, and thus neither ethical approval nor individual consent was applicable.

Availability of materials

All data used in this study were publicly available.

Consent for publication

Not applicable.

Disclaimer

The funding agencies had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

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Conflict of interests

D He is an associate editor of Infectious Disease Modelling. He was not involved in the editorial process.

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