Comparative Analysis of Human-to-Human Transmission in Two Different Population Settings (Community and Healthcare): A Mathematical Modelling Approach

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ECOWAS LASSA FEVER INTERNATIONAL CONFERENCE

Background

- Lassa fever (LF) is a viral haemorrhagic disease endemic in West Africa, spread from *Mastomys natalensis* rodents and through human-to-human contact.
- Annually causes ~300,000 infections and 5,000–10,000 deaths; severe disease has high mortality despite most cases being mild.
- Community spread occurs during caregiving, burials, and household contact; healthcare spread is linked to poor PPE use, overcrowding, and direct patient contact.
- In Nigeria, high-burden states include Ondo and Edo; medium-burden states include Plateau, Benue, and Kogi low-burden states include Zamfara, Yobe, and Osun
- This study applies **mathematical modelling** to compare LF transmission in community vs healthcare settings to guide targeted control.

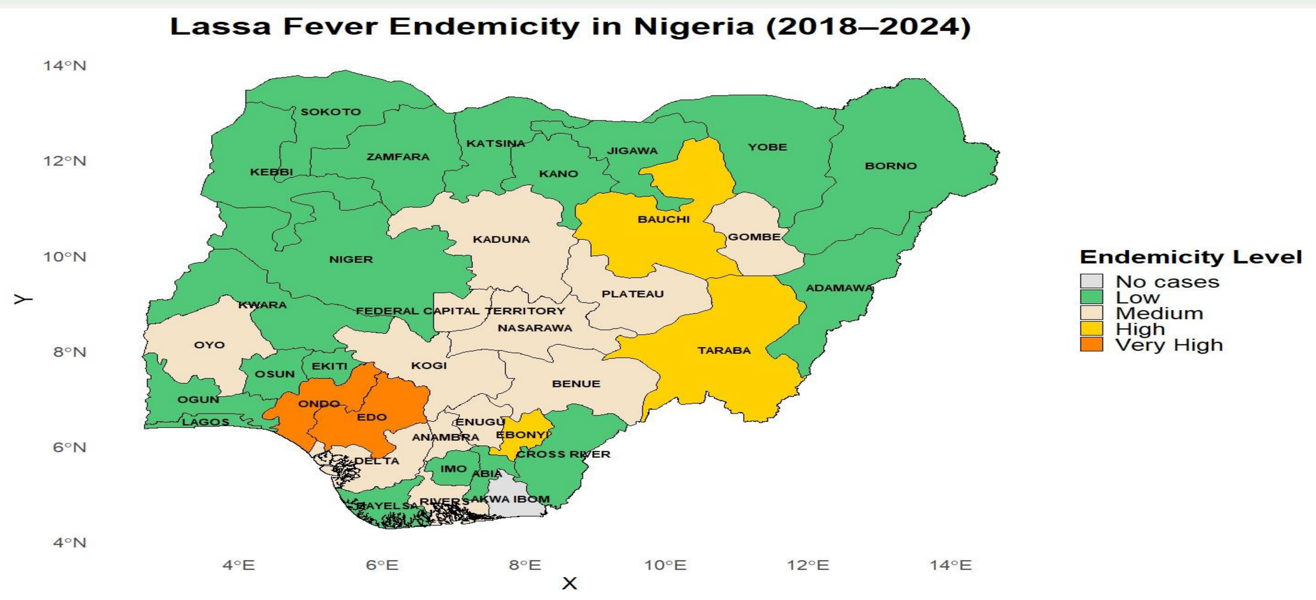

Figure 1: Lassa Fever Endemicity in Nigeria (2018-20124

Methods

Study Overview

This cross-sectional analytical study used NCDC surveillance data (2018–2024) from low-transmission settings. A modified **SEIR model** compared community and healthcare transmission, incorporating intervention effects.
Data analysis was conducted using R and Excel.

Workflow:
NCDC Data ⟶ Model Development ⟶ Parameter Estimation ⟶ Scenario Comparison

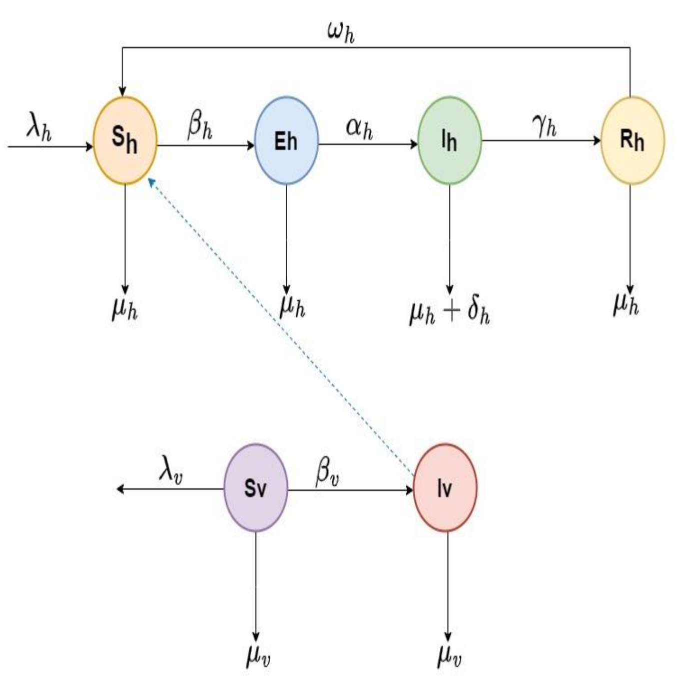

Figure 2:Schematic description of the mathematical model

Key Assumptions

- Susceptible humans can be infected by exposed individuals.
- Recovered individuals have temporary immunity.
- Mixing is homogeneous within each setting.
- Transmission rates differ between community and healthcare environments.

Model Equations

Human compartment

$$dS_h/dt = \Lambda_h - (\beta_h S_h I_h) / N_h - \mu_h S_h + \omega_h R_h$$
$$dE_h/dt = (\beta_h S_h I_h) / N_h - \alpha_h E_h - \mu_h E_h$$
$$dI_h/dt = \alpha_h E_h - \gamma_h I_h - \delta_h I_h - \mu_h I_h$$
$$dR_h/dt = \gamma_h I_h - \omega_h R_h - \mu_h R_h$$

Vector compartment

$$dS_v/dt = \Lambda_v - (\beta_v S_v I_v) / N_v - \mu_v S_v$$
$$dI_v/dt = (\beta_v S_v I_v) / N_v - \mu_v I_v$$

Key Parameters

λ_h (4,4)
β_h (0.101,0.40)
μ_h (0.000045, 0.000045)
ω_h (0.00578, 0.03)
α_h (0.000904, 0.20)
γ_h (0.05, 0.05)
δ_h (0.0000904, 0.15)
λ_v (0.0159675,0.000045)
β_v (0.052, 0.052)
μ_v (0.003, 0.003)

Format: (Community, Healthcare)

Results

Transmission Dynamics

The basic reproduction numbers (R_0) indicate slightly higher Lassa fever transmission potential in **healthcare facilities** (R_0 = 1.9991) compared to **community settings** (R_0 = 1.9822).

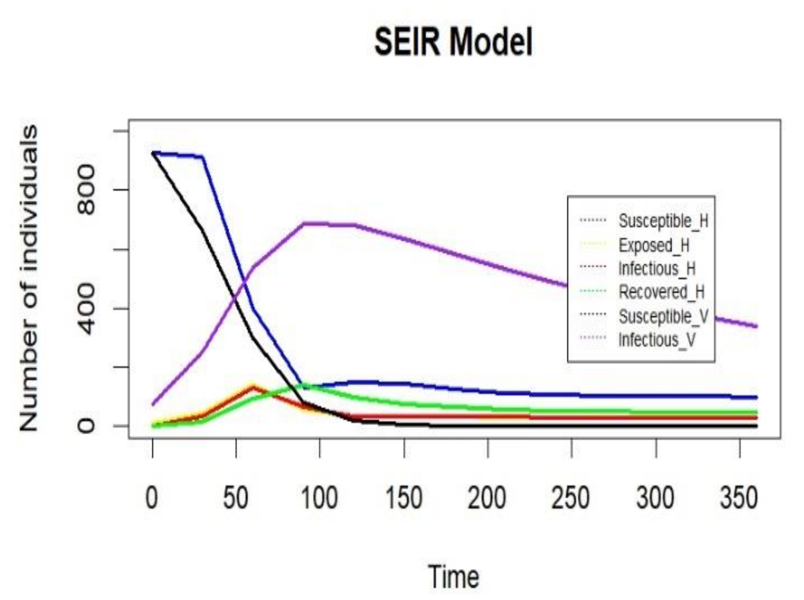

Figure 3: Healthcare settings: show faster transmission peaks, driven by close patient contact, poor PPE use, and overcrowding.

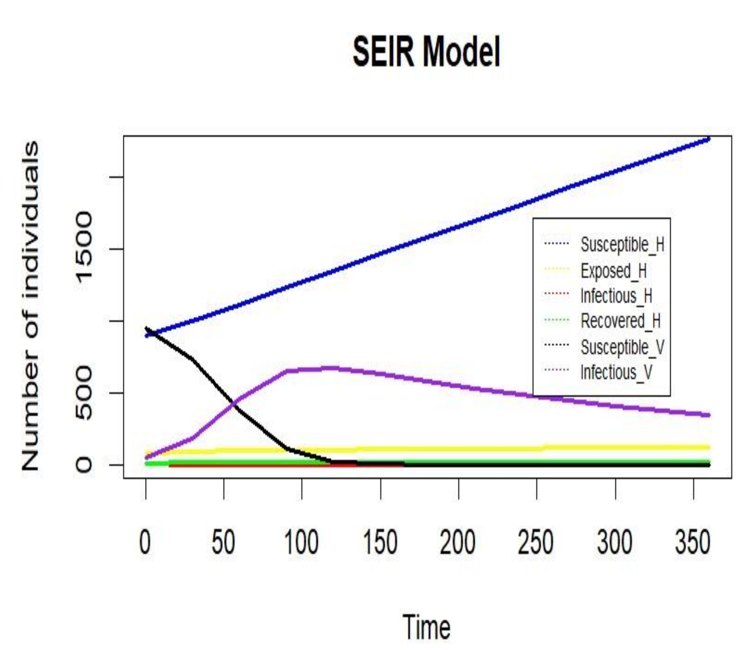

Figure 4: Community settings :exhibit slower transmission but still sustain the epidemic, especially with asymptomatic carriers

Sensitivity Analysis

- In healthcare settings, human-to-human transmission rate (β_h) had the strongest positive influence, while recovery rate (γ_h) had a strong negative effect.
- In community settings, (γ_h) similarly had the greatest negative impact, while other parameters had minimal effect

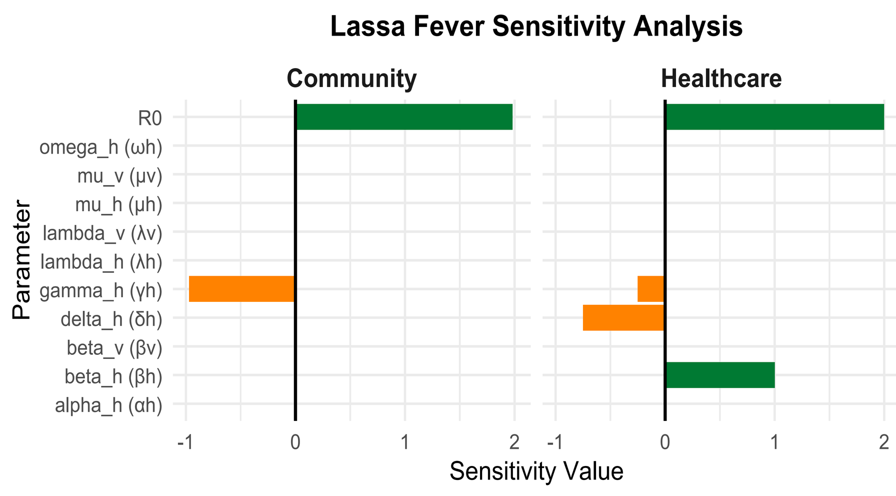

Figure 5: presents the sensitivity analysis results—green bars for parameters that increase R_0 and orange bars for those that reduce R_0.

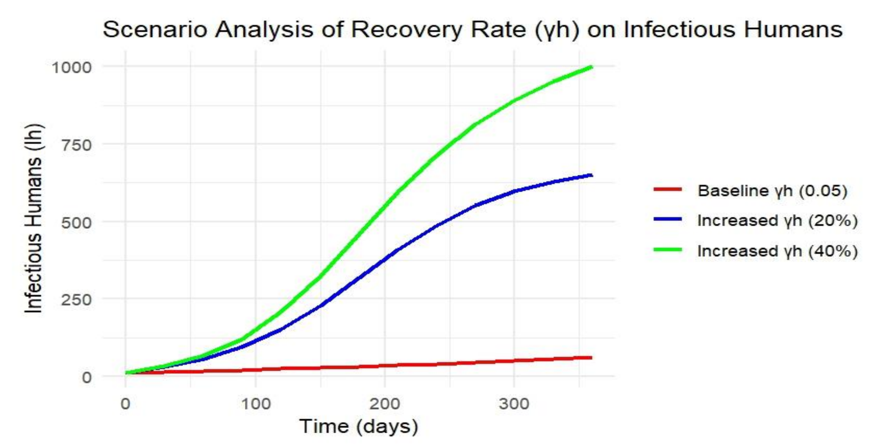

Figure 6: Increasing γ_h by 20–40% significantly reduces the number of infectious humans over time

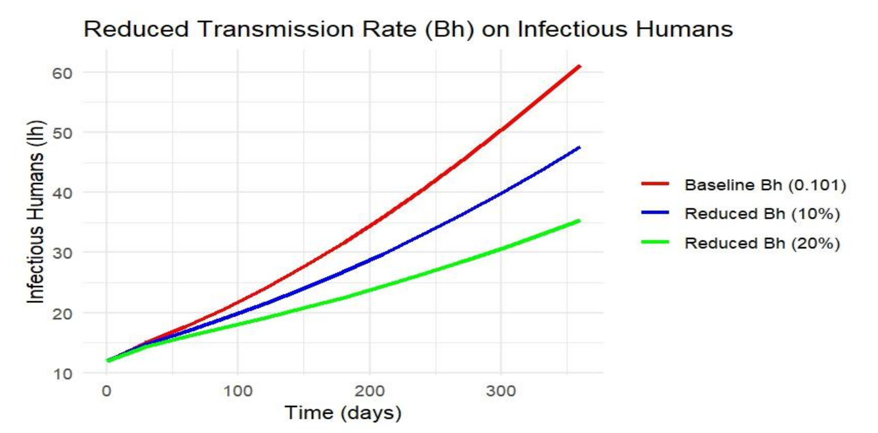

Figure 7: Reducing β_h by 10–20% also markedly lowers transmission

Conclusions and Recommendations

Conclusion

- Lassa fever transmission is slightly higher in healthcare settings (R_0 = 1.9991) than in communities (R_0 = 1.9822), but both pose serious risks.
- Healthcare spread is driven by close contact and poor PPE use; community spread persists via asymptomatic carriers.
- Reducing transmission rate (β_h) or increasing recovery rate (γ_h) significantly lowers outbreak size.

Recommendations

- Healthcare settings: Enforce PPE use, early isolation, and routine HCW screening.
- Communities: Boost awareness, hygiene, and rodent control; expand testing access.
- Policy: Integrate modelling into preparedness plans and strengthen One Health surveillance.

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