Assessing the effects of modeling the spectrum of clinical symptoms on the dynamics and control of Ebola

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Mathematical modelers have attempted to capture the dynamics of Ebola transmission and to evaluate the effectiveness of control measures, as well as to make predictions about ongoing outbreaks. Many of their models consider only infections with typical symptoms, but Ebola presents clinically in a more complicated way. Even the most common symptom, fever, is not experienced by 13% of patients. This suggests that infected individuals could be asymptomatic or have moderately symptomatic infections as reported during previous Ebola outbreaks. To account crudely for the spectrum of clinical symptoms that characterizes Ebola infection, we developed a model including moderate and severe symptoms. Our model captures the dynamics of the recent outbreak of Ebola in Liberia. Our estimate of the basic reproduction number is 1.83 (CI: 1.72, 1.86), consistent with the WHO response team's estimate using early outbreak case data. We also estimate the effectiveness of interventions using observations before and after their introduction. As the final epidemic size is linked to the timing of interventions in an exponential fashion, a simple empirical formula is provided to guide policy-making. It suggests that early implementation could significantly decrease final size. We also compare our model to one with typical symptoms by excluding moderate ones. The model with only typical symptoms overestimates the basic reproduction number and effectiveness of control measures, and exaggerates changes in peak size attributable to the timing of interventions. In addition, uncertainty about how moderate symptoms affect the basic reproduction number is considered, and PRCC (Partial rank correlation coefficient) is used to analyze the global sensitivity of relevant parameters. Possible control strategies are evaluated through numerical simulations and sensitivity analysis, indicating that simultaneously strengthening contact-tracing and effectiveness of isolation in hospital would be most effective. In this study, we show the impact of considering asymptomatic individuals in the model has implications for policy-making.