

Enhancing Ring Vaccination with Individual Risk Prioritization: A Case Study of the 2014 West Africa Ebola Outbreak

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Abstract:

During an infectious disease crisis, resources used to slow spread are often scarce and expensive. Designing control policies is difficult, particularly early in the outbreak, when key information about index cases and their contacts is missing. In light of these challenges, ring vaccination, a strategy that consists in vaccinating contacts of infected individuals and their contacts, has been proposed to reduce morbidity and mortality while managing costs. We study its application in the context of Ebola virus disease (EVD) and propose several extensions. To simulate realistic outbreaks in a representative population, we use an agent-based model (ABM) informed by sociodemographic and contact data from sub-Saharan Africa. We improve on standard ring vaccination with in-ring prioritization based on household size or contact type. Additionally, we compute each individual's success probability ---the propensity that receiving a vaccine dose will prevent them from becoming infected, given recent or subsequent exposures. Assuming known transmission risk by contact type and constant daily vaccine supply, we compare our proposed in-ring prioritization strategies against random vaccination and standard ring vaccination. We show that standard ring vaccination outperforms random vaccination early in the outbreak, averting the number of infections by 5-13% in the first 100 days, but wanes after 300 days. Conversely, our in-ring prioritization policies outperform both baselines, reducing total morbidity after 300 days by 2-18% across the considered experimental settings. Prioritization by success probability yields the largest improvement (9-18%), followed by prioritization by contact type (3-13%) and by household size (2-10%).