Using mathematical models and R_0 to better understand epidemics: the 2008-2009 cholera outbreak in Zimbabwe

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Cholera remains an important global cause of morbidity and mortality, capable of causing periodic epidemic disease. A number of mathematical models have been developed to help in understanding the dynamics of cholera outbreaks. However, most are based on data from countries/regions in coastal or estuarine areas, such as Bangladesh.

Beginning in August, 2008, a major cholera epidemic occurred in Zimbabwe, with 98,585 reported cases and 4,287 deaths. We explored the utility of mathematical models in understanding transmission of cholera in this land-locked country, and in assessing the magnitude of interventions necessary to control epidemic disease. Weekly data on reported cholera cases were obtained from the Zimbabwe Ministry of Health and Child Welfare (MoHCW) for the period from 13 November 2008 to 31 July 2009. A mathematical model was formulated and fitted to cumulative cholera cases to estimate the basic reproductive numbers $\mathscr{R}_0$, and the partial reproductive numbers (reflecting potential differences in environmental to human vs. human to human transmission) from all 10 provinces for the 2008-2009 epidemic. Estimated basic reproductive numbers were highly heterogeneous, ranging from a low value of just above unity to 16.6.

Our models suggest that the underlying patterns of cholera transmission varied widely from province to province, with a corresponding variation in the amenability of outbreaks to control measures such as immunization. These data underscore the heterogeneity of transmission dynamics, potentially linked to differences in environment, socio-economic conditions, and cultural practices; they also highlight the potential utility of these types of models in guiding development of public health intervention models.