Geophysical Research Abstracts
Vol. 21, EGU2019-5774, 2019
EGU General Assembly 2019

Rainfall as a driver of epidemic cholera: comparative model assessments of the effect of intra-seasonal precipitation events

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The correlation between cholera epidemics and climatic drivers, in particular seasonal tropical rainfall, has been studied in a variety of contexts owing to its documented relevance. Several mechanistic models of cholera transmission have included rainfall as a driver by focusing on two possible transmission pathways: either by increasing exposure to contaminated water (e.g. due to worsening sanitary conditions during water excess), or water contamination by freshly excreted bacteria (e.g. due to washout of open-air defecation sites or overflows). Our study assesses the explanatory power of these different modeling structures by formal model comparison using deterministic and stochastic models of the type susceptible-infected-recovered-bacteria (SIRB). The incorporation of rainfall effects is generalized using a nonlinear function that can increase or decrease the relative importance of the large precipitation events. Our modelling framework is tested against the daily epidemiological data collected during the 2015 cholera outbreak within the urban context of Juba, South Sudan. This epidemic is characterized by a particular intra-seasonal double peak on the incidence in apparent relation with particularly strong rainfall events. Our results show that rainfall-based models in both their deterministic and stochastic formulations outperform models that do not account for rainfall. In fact, classical SIRB models are not able to reproduce the second epidemiological peak, thus suggesting that it was rainfall-driven. Moreover we found stronger support across model types for rainfall acting on increased exposure rather than on exacerbated water contamination. Although these results are context-specific, they stress the importance of a systematic and comprehensive appraisal of transmission pathways and their environmental forcings when embarking in the modelling of epidemic cholera.