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Seasonality in cholera dynamics : a rainfall-driven model explains the wide range of patterns of an infectious disease in endemic areas

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An explanation for the spatial variability of seasonal cholera patterns has remained an unresolved problem in tropical medicine [**?**]. Previous studies addressing the role of climate drivers in disease dynamics have focused on interannual variability and modelled seasonality as given [**?**]. Explanations for seasonality have relied on complex environmental interactions that vary with spatial location (involving regional hydrological models [**?**], river discharge, sea surface temperature, and plankton blooms). Thus, no simple and unified theory based on local climate variables has been formulated [**?**], leaving our understanding of seasonal variations of cholera outbreaks in different regions of the world incomplete.

Through the analysis of a unique historical dataset containing 50 years of monthly meteorological, demographic and epidemiological records, we propose a mechanistic, SIR-based stochastic model for the population dynamics of cholera driven by local rainfall and temperature that is able to capture the full range of seasonal patterns in this large estuarine region, which encompasses the variety of patterns worldwide. Parameter inference was implemented via new statistical methods that allow the computation of maximum-likelihood estimates for partially observed Markov processes through sequential Monte-Carlo [**?**]. Such a model may provide a unprecedented opportunity to gain insights on the conditions and factors responsible for endemicity around the globe, and therefore, to also revise our understanding of the ecology of *Vibrio cholerae*.

Results indicate that the hydrological regime is a decisive driver determining the seasonal dynamics of cholera. It was found that rainfall and longer water residence times tend to buffer the propagation of the disease in wet regions due to a dilution effect, while also enhancing cholera incidence in dry regions. This indicates that overall water levels matter and appear to determine whether the seasonality is uni- or bimodal, as well as whether it is pre-, post-, or in-phase with the monsoon [**?**]. We present evidence that the environmental reservoir is responsible for the persistence of the disease, and therefore its endemicity.

Given the interplay between the seasonality of cholera and the environment, a deeper understanding of the underlying mechanisms could allow for the better management and planning of public health policies with respect to climate. We provide an interpretation of those dynamics and discuss their implications. In terms of disease prevention and mitigation strategies this is of paramount importance today, as changes in the population dynamics of infectious diseases are expected in response to fast anthropogenic climate change.

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