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Hydroepidemiology of Cholera Transmission in Bangladesh: A Spatially Explicit and Seasonally Varying Cholera Prevalence Model

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Despite major advances in the ecological and microbiological understanding of Vibrio cholerae, the causative agent of cholera, the role of underlying large-scale hydroclimatic processes in propagating the disease in different seasons and spatial locations is not well understood. A coupled analysis of the regional hydroclimate and long-term cholera incidence reveals a strong association of the space-time variability of incidence peaks with seasonal processes and extreme climatic events. We attempt to explain how an asymmetric seasonal hydroclimatology may affect regional cholera dynamics by providing a coastal growth environment for bacteria in spring, while propagating the disease to fall by flooding in a cyclic manner. The seasonal and spatial processes indicate a spring-to-fall and coast-to-inland transmission cycle, contrary to the prevalent knowledge of a fall-spring pattern.

Here, we present a coupled hydrology, climatology, and epidemiology model for the simulation of local and regional scale cholera prevalence in response to large scale hydrological and climatological forcings in the Bengal Delta region. The semi-distributed hydroclimatological model is applied to the Ganges-Brahmaputra-Meghna Basin areas in Bangladesh and coupled with a regional scale epidemiological model to simulate the seasonal cholera prevalence rates in nine 1°x1° spatial grids spanning the region. Long term cholera surveillance records from Dhaka and recent short-term records from regional surveillance locations are used to develop and validate the model results, respectively. The model reproduces the variability of cholera prevalence at seasonal and interannual timescales and highlights the role of the seasonal asymmetric large scale processes as the dominant controls of cholera transmission. This interpretation of the seasonal progression of infection has important policy implications, for formulating effective cholera intervention through water management and for understanding the impacts of extreme hydroclimatic events such as droughts and floods, and changing climate patterns on seasonal transmission. Our findings may serve as the basis for "climate-informed" early warnings, and prompting effective means for intervention and preempting epidemic cholera outbreaks in vulnerable regions.