Hydroepidemiology of Cholera Transmission in Bangladesh

A Spatially Explicit and Seasonally Varying Cholera Prevalence Model

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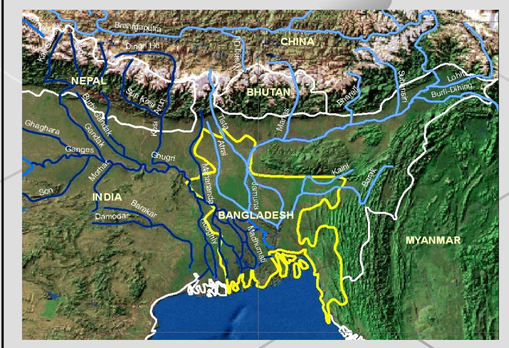
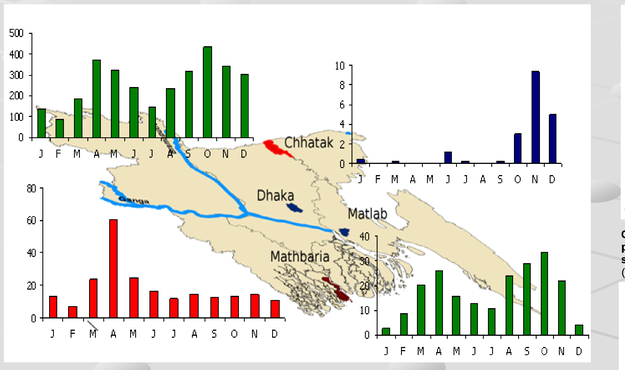
Abstract

- Despite major advances in the microbiological & ecological understanding of *Vibrio cholerae*, the role of the underlying large-scale hydroclimatic processes in propagating the cholera disease in different seasons is not well understood.
- We explain how regional asymmetric seasonal hydroclimatology of the Bengal Delta region may affect regional cholera dynamics by providing a coastal growth environment for bacteria in spring, and propagating to north and central regions by flooding in autumn.
- Here we present a coupled hydroclimatology and epidemiology model for the simulation of local and regional scale cholera prevalence in response to large scale hydroclimatic forcings in the Bengal Delta region.
- The model is used to simulate seasonal and monthly cholera prevalence in nine 1ºx1º spatial grids spanning Bangladesh. Long term cholera surveillance records from the ICDDRB hospital in Dhaka and short-term records from surveillance locations are used to validate the model.
- Our results have important policy implications, formulating effective cholera intervention through water management and understanding the impacts of extreme hydroclimatic events such as droughts and floods, and changing climate patterns on seasonal transmission.

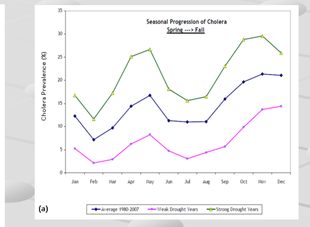


Ganges (Dark Blue) and Brahmaputra (Light Blue) Basin Region

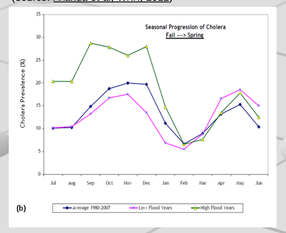


The incidence of cholera in the Bengal Delta region shows distinct seasonal and spatial variations

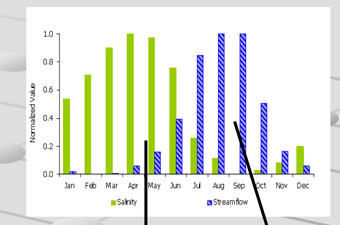
Monthly climatology of cholera incidence recorded at Dhaka, Mathbaria, Chhatak, & Matlab in Bangladesh (Source: Akanda et al, WRR, 2011)



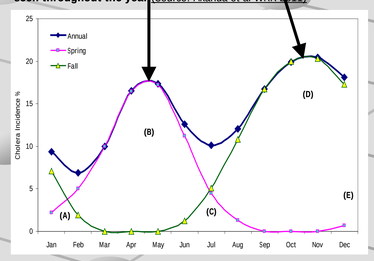
Comparison of seasonal progression of cholera prevalence from Spring to Fall months between strong and weak drought years (Source: Akanda et al, WRR, 2011)

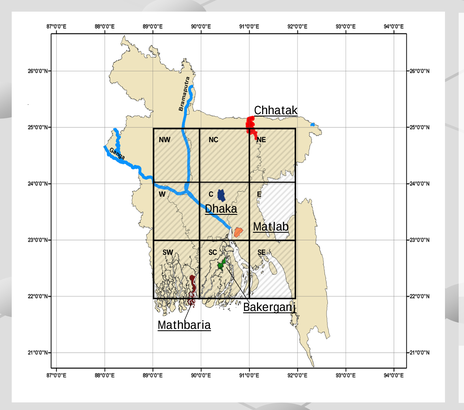


Comparison of seasonal progression of cholera prevalence from Fall to Spring months between High and Low Flood years (Akanda et al WRR 2011)

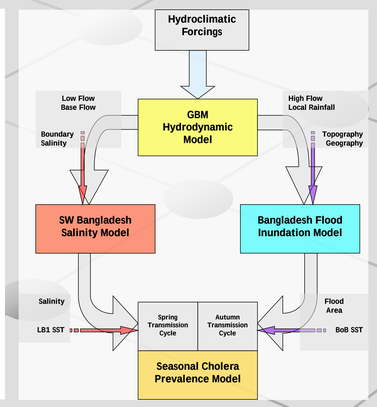


Hypothesized schematic of seasonal cholera transmission cycles during spring and fall months; the separate transmission cycles together correspond to the total amount of cholera prevalence seen throughout the year (Source: Akanda et al WRR 2011)

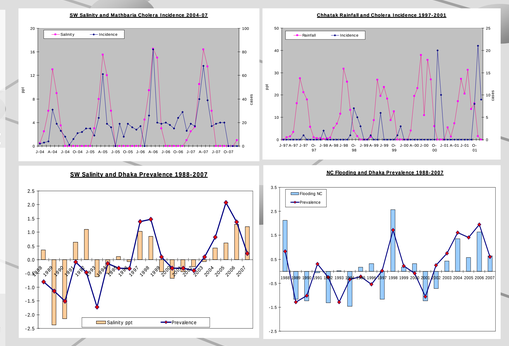




Model Domain: Nine 1x1 degree grids spanning cholera affected regions of Bangladesh



Model Configuration composed of 4 Modules: Hydrodynamic – Salinity – Flood– Prevalence



Model Salinity, Rainfall, and Flooding relationships with local cholera incidence and regional cholera prevalence

Reference

- Akanda, A.S., A.S. Jutla & S. Islam (2009). Dual Peak Cholera Transmission in Bengal Delta: A Hydroclimatological Explanation. *Geophysical Research Letters*, 36, L19401.
- Jutla, A.S., A.S. Akanda, & S. Islam (2010). Tracking Cholera in Coastal Regions using Satellite Observations. *Journal of American Water Resources Association*, 46(4):651-662.
- Akanda, A.S., A.S. Jutla. G. Constantin de Magny, M. Alam, A. Kasem Siddique, A. Huq, R.B. Sack, R.R. Colwell, & S. Islam. 2011 Hydroclimatic Influences on Seasonal and Spatial Cholera Transmission Cycles: Implications for Public Health Intervention in the Bengal Delta. *Water Resources Research*, Paper in Press.

Data

- *Cholera*: Monthly time series of percent cholera incidence from ICDDR,B (1980-2009).
- *Streamflow*: Observed daily streamflow data for the Ganges and the Brahmaputra from BUET (1956-2007).
- *Sea Surface Temperature*: Reynolds 1ºx1º Global SST Observation and AVHRR Interpolated Datasets.
- *Salinity and Flood Affected Area:* Institute of Water Modeling, Dhaka, Bangladesh (1988-2007)
- *Precipitation*: NCEP/NCAR, UDel Gridded Precipitation Datasets from NOAA Depository (1948-2009).
- *Phytoplankton*: SeaWiFS 9x9km Chlorophyll-a data (1997-2009).

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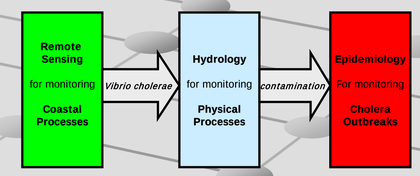
Creating Actionable Knowledge Through Reliable, Relevant, & Robust Forecasts

The overarching goal of our research is to develop a Cholera Early Warning System with 2-3 months lead time for Bengal Delta



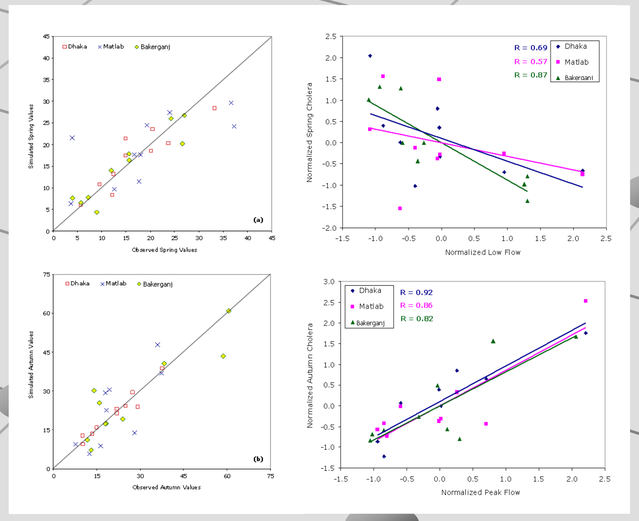
A Schematic Diagram of Our Proposed Research Methodology

By synthesizing:

Recent Advances in Satellite Remote Sensing

Adaptive Understanding of Large Scale Hydroclimatic Processes

Ecological and Epidemiological Evidence of Vibrio Growth and Exposure



Simulated Cholera Incidence for Matlab and Bakerganj and Dhaka Cholera Prevalence

Relationship of Regional Streamflow and Simulated Cholera Incidence for Matlab, and Bakerganj, and Prevalence in Dhaka

Effective implementation of Cholera Warning System will provide 2-3 months lead-time to facilitate quick intervention, and save lives