Predictive assessment of transmission conditions of cholera in the environment and human population using earth observations

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DfID, UK-Africa operations
UK Met Office
OCHA
UNICEF
Goal of Research Project

We thematically envision “Cholera Ready Nations” where satellite based prediction (of risk of trigger and likelihood of transmission of cholera in the human population) will provide sustainable and resilient readiness to prevent outbreak of disease, saving human lives and improving quality of life.

Objectives

• Systematically validate the epidemic and endemic cholera hypothesis for trigger component of cholera in Africa
• Develop, calibrate, and validate predictive model for transmission component of cholera.
**Research Pathway**

**Relevant earth observations**
- **EPIDEMIC CHOLERA**
  - MODIS/VIIRS [LST, Land cover]
  - TRMM/GPM [Precipitation]
  - SRTM [DEM]
- **ENDEMIC CHOLERA**
  - MODIS/VIIRS [Chlorophyll, SST, Organic matter, Land Cover]
  - AVHRR [SST]
  - TRMM/GPM [Precipitation]
  - SRTM [DEM]
  - TOPEX/JASON [SSH]
  - Aquarius [Salinity]

*SST*: Sea Surface Temperature; *SSH*: Sea Surface Height; *LST*: Land Surface Temperature; *MODIS*: Moderate Resolution Imaging Spectroradiometer; *TRMM*: Tropical Rainfall Measuring Mission; *GPM*: Global Precipitation Mission; *AVHRR*: Advanced Very High Resolution Radiometer; *DEM*: Digital Elevation Model; *SRTM*: Shuttle Radar Topography Mission

**Use of earth observations to advance science of cholera (Section 2.1)**

- Validation of trigger hypothesis for Epidemic mode of cholera (Task 1)
- Validation of trigger hypothesis for Endemic mode of cholera (Task 2)

**Cholera Transmission Model (CTM) (Task 3)**

**Anticipated Results (Section 3)**
- Risk maps showing probabilities of occurrence of inland cholera infection
- Risk maps showing probabilities of occurrence of cholera infection along coasts
- Ensemble scenarios on how cholera infection may spread in human population

**Capacity building initiatives (Section 2.2)**
- Communication plan with African partners identified by GEO Secretariat to identify core working group for cholera (Task 4)
- Determine feasibility of encourage use of earth observations and testing algorithms by partner foundations (Task 5)
- Workshop on African Cholera Initiative, social media and dissemination kit to advance Agenda 2030 plan (Task 6)
Epidemic cholera model

**Normal or Low Temperature**
- Warm Temperature
  - 4 Weeks
  - MERRA-2
  - NOAA-NCEP

**Normal or Low Rainfall**
- Heavy Rainfall
  - 4 Weeks
  - NRT-GPM

**Cholera Risk 0.1°x0.1°**
- High Cholera Risk
  - Water Insecurity
  - WHO
  - UNICEF
  - NASA-SEDAC

**Low Cholera Risk**
- Water Security

Warm temperature = above climatological average temperature
Heavy rainfall = above climatological average precipitation
Water insecurity = lack of access to water and sanitation access
High cholera risk = probability of cholera greater than 50%
Epidemic algorithm: Hydrology + Microbiology + Sociology

CHOLERA ALERT SYSTEM (CAS-version 4)

Air temperature anomalies

Precipitation anomalies

Population density

Disaster and population movement

Drinking water accessibility

Sanitation infrastructure

\( W_{i,j} \)

\( i = \text{variable of interest} \)

\( j = \text{risk level} \)

Cholera Risk Map

Hydrology + Microbiology + Sociology
India Bangladesh Cholera Risk May 25- June 21

Additional validation point
How to interpret “Level of Threat” and “What to Do”?

**Level of Threat**: The four categories of threat level include

<table>
<thead>
<tr>
<th>Threat Level</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing</td>
<td>Overall risk of cholera is increasing in several regions</td>
</tr>
<tr>
<td>Stable</td>
<td>Risk of cholera is stable with respect to the previous forecast</td>
</tr>
<tr>
<td>Decreasing</td>
<td>Overall risk of cholera is decreasing in several regions</td>
</tr>
<tr>
<td>Decreasing-Stable</td>
<td>Overall cholera risk remains very low</td>
</tr>
</tbody>
</table>

**What to Do**

<table>
<thead>
<tr>
<th>What to Do</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strengthen WASH</td>
<td>Immediate need to provide WASH and education to high risk communities</td>
</tr>
<tr>
<td>Stable WASH</td>
<td>Keep providing WASH and education, given the risk exists but not at an alarming level</td>
</tr>
<tr>
<td>Sustain WASH</td>
<td>Low cholera risk and an opportunity to develop policies for sustaining WASH and education then in community.</td>
</tr>
</tbody>
</table>
Cholera Transmission Module

- **Low trigger risk**
  - Data Source: MERRA-2, NOAA-NCEP, Met-Office, GPM, WHO, UNICEF, WorldPop

- **Low probability of contagion**
  - Data Source: GPM, Met Office

- **Triggering mechanism**
  - t+4 Weeks

- **Contagion**
  - t+4 Weeks

- **High Risk of Cholera Transmission**
  - Output: Cholera Risk 250mx250m

- **Socio-demography**
  - Data Source: WorldPop, IDP

- **Low Cholera Spread Risk**

- **Stable Socio-Demographics**
Correlation between actual cholera cases and trigger and transmission module of CPS. X-axis shows the name of governorate followed by total number of cholera cases for first 28 weeks of 2019
Changing dynamics of cholera

Cholera Cases

- Data 2018
- Data 2019

Reported Number of Cases

- week 1 to week 45
ARL information

Starting ARL: 3

Current ARL: 6 (approaching 7)

Target ARL: 8
Overall timeline for research objective and activities at end user organization

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>Kick off meeting (Skype)</td>
<td>C</td>
<td></td>
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</tr>
<tr>
<td>Task 1: Epidemic cholera</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Task 2: Endemic cholera</td>
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<td>C</td>
<td>IP</td>
</tr>
<tr>
<td>Task 3: CTM</td>
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<td>IP</td>
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<tr>
<td>Task 4: Core group formation</td>
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<td>C</td>
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<tr>
<td>Task 5: Training/ dissemination plan with</td>
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<tr>
<td>foundations</td>
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<tr>
<td>Task 6: Workshop</td>
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<tr>
<td>PI meeting</td>
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<tr>
<td>Meetings with stakeholders (OCHA, DfID)</td>
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</tbody>
</table>

x¹ : planning; *: status unknown due to COVID19
UF; Q1, Q2, Q3, Q4 represent quarter in a given year.
Thank you