

# YEMEN CHOLERA CRISIS: Conflict Impact on Cholera Outbreaks

## Research Question

### Yemeni formula: Conflict × Cholera

In July 2017, a cholera pandemic struck the war-affected population of Yemen, quickly infecting over six million people over the next six months. The pre-existing weaknesses in sanitary and health infrastructures have manifested in the wake of the pandemic, but what differentiates the Yemeni cholera pandemics is the decisive impact of conflict. Since Houthi rebels have taken Sana'a in late 2014, Saudi airstrikes on Houthi strongholds have caused massive suffering. Seven million Yemenis live in areas that are close to famine, nearly two million children are under threat of acute malnutrition, and over three million have been displaced. This project analyzes how the conflict-induced factors such as famine, displacement, humanitarian access have affected the outbreak of cholera in addition to traditional explanations of cholera outbreaks.

## Methods & Analysis

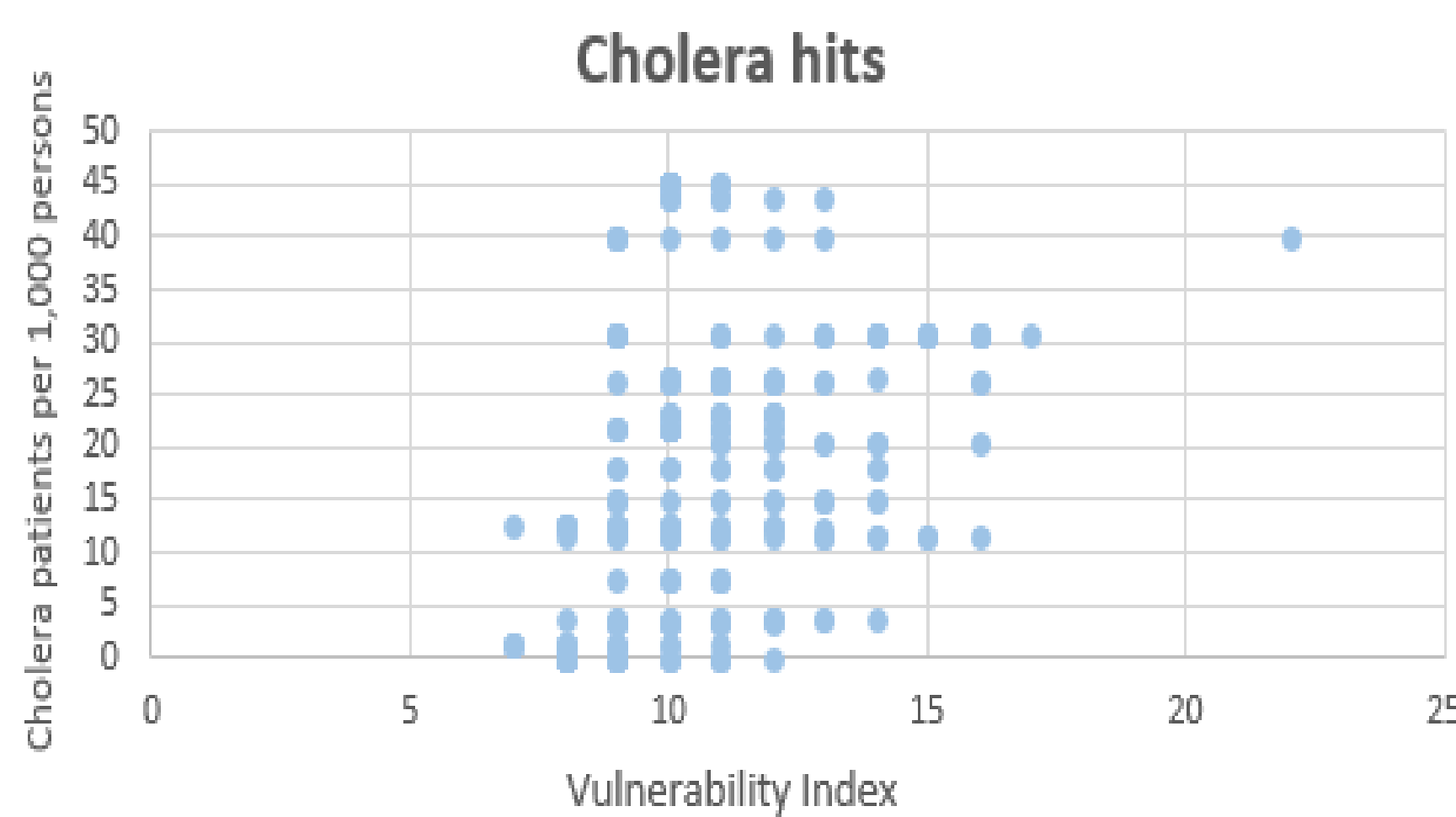
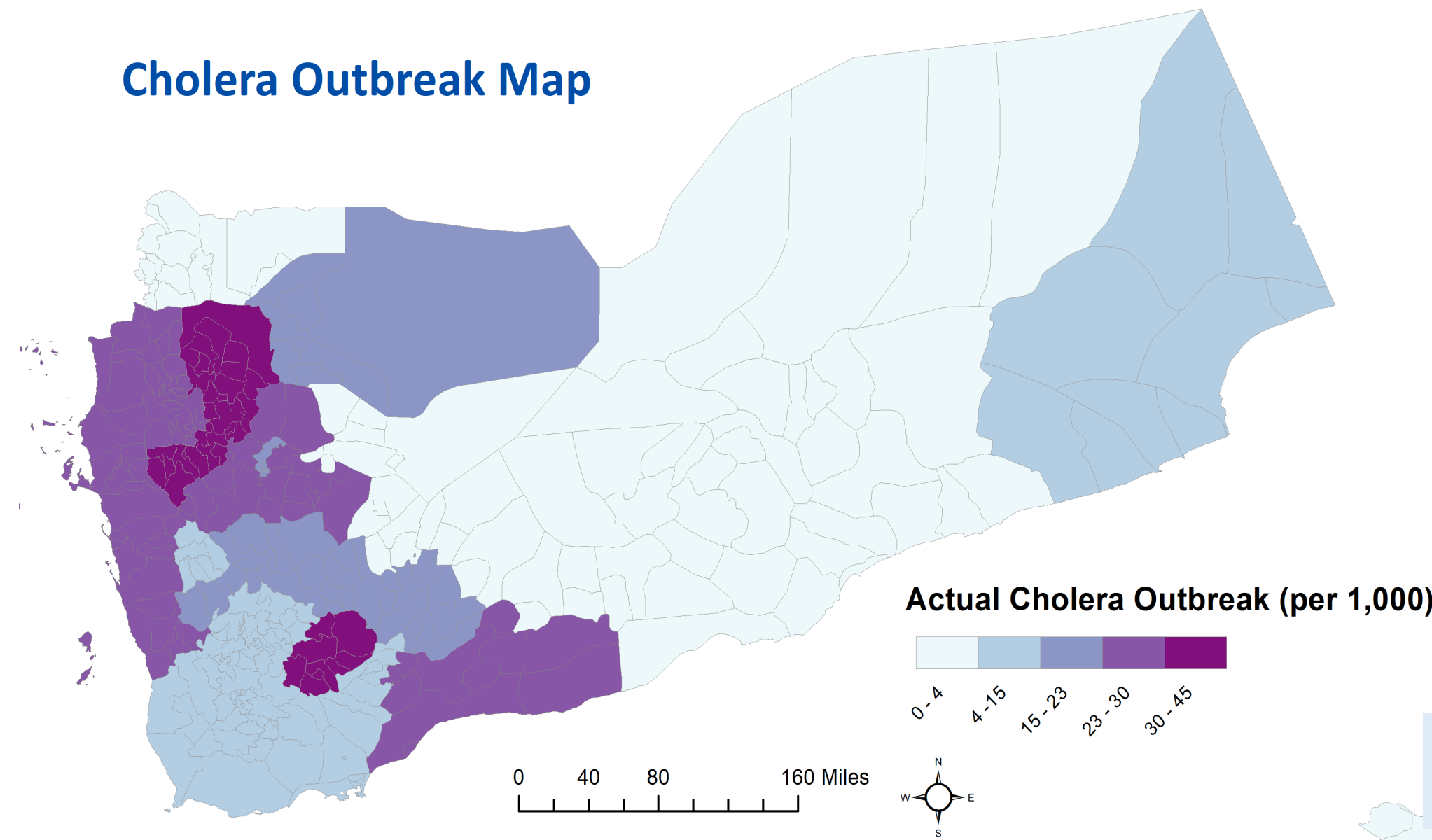
### Vulnerability Mapping and Actual Outbreak

This Project conducts a cholera vulnerability mapping, and contrasts the results of the risk-map with actual cholera attacks. The vulnerability map will be made based on a summation of the standardized vulnerability scores (1-4) of different factors which raise the risks of cholera outbreak, and be disaggregated at the district level. The vulnerability factors will be calculated based on the levels of January - June 2017, which is a month before the spread of cholera, so that it indicates the risk factors which pre-existed in Yemen before the outbreak. In choosing the risk factors, this project considers traditional cholera risk-factors such as population density, medical facilities and sanitation levels, but also add four conflict-induced factors which will likely affect cholera outbreak; malnutrition levels, flow of refugees, conflict events and humanitarian access blocks.

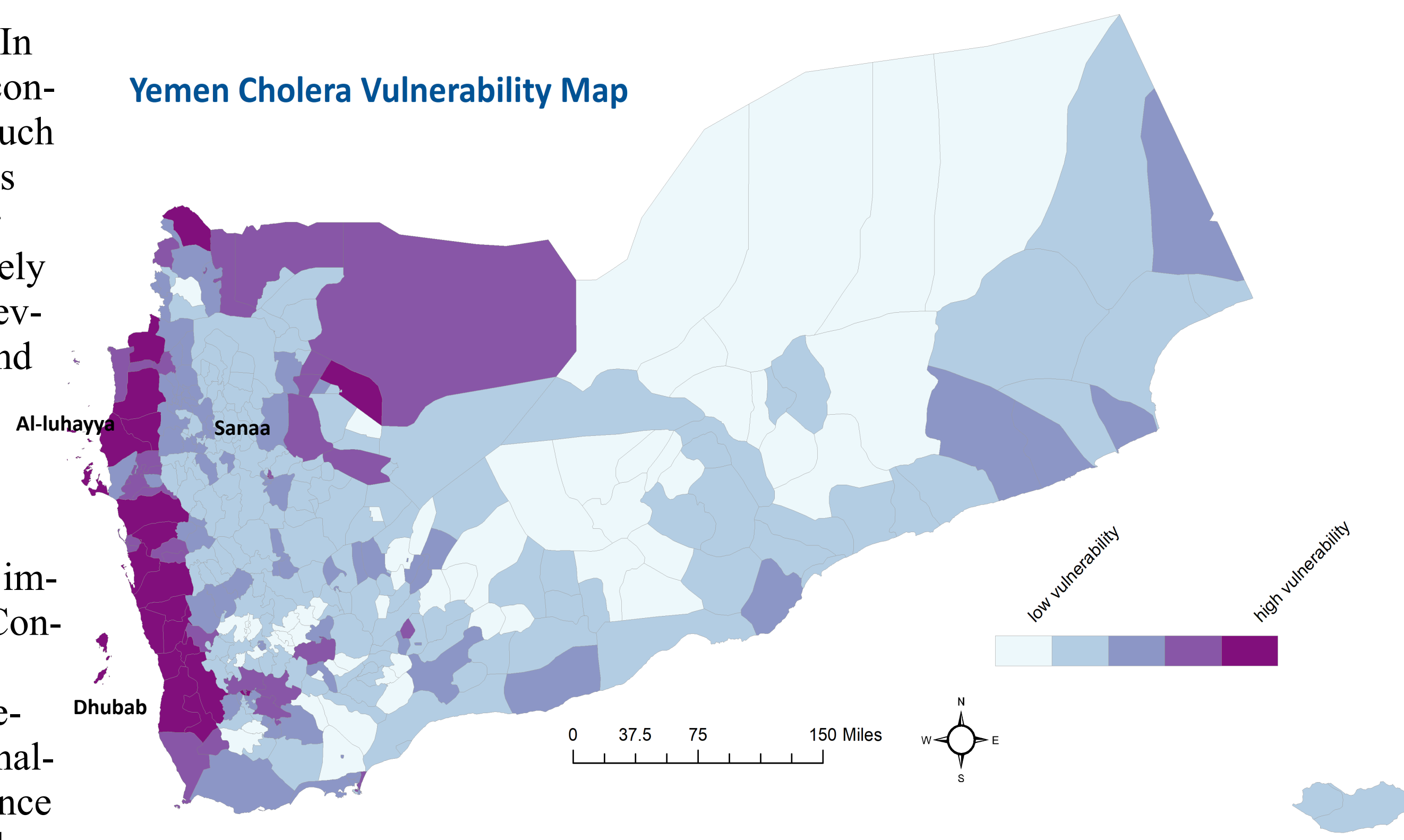
### Conflict Risk Factors

Malnutrition levels are included in the vulnerability score, since it lowers the immunity of the population to diseases. Conflict intensity and humanitarian access blocks render it difficult for a timely response in the wake of emergencies. Finally, the flow of refugees are included since the mass influx of persons increase risks of contagion.

Outbreak data based on July 2017—June 2018



Yemen Cholera Vulnerability Map



## Vulnerability Index ( 7 - 28)

- Population Density
- Medical Facilities (Number of Hospitals)
- WASH infrastructure (WASH assistance needs)
- Malnutrition levels (Nutrition assistance needs)
- Refugees (refugee per host population)
- Conflict events
- Humanitarian Access Blocks (UN aid blocks)

## Findings & Future Research

### Results: Conflict-induced vulnerability

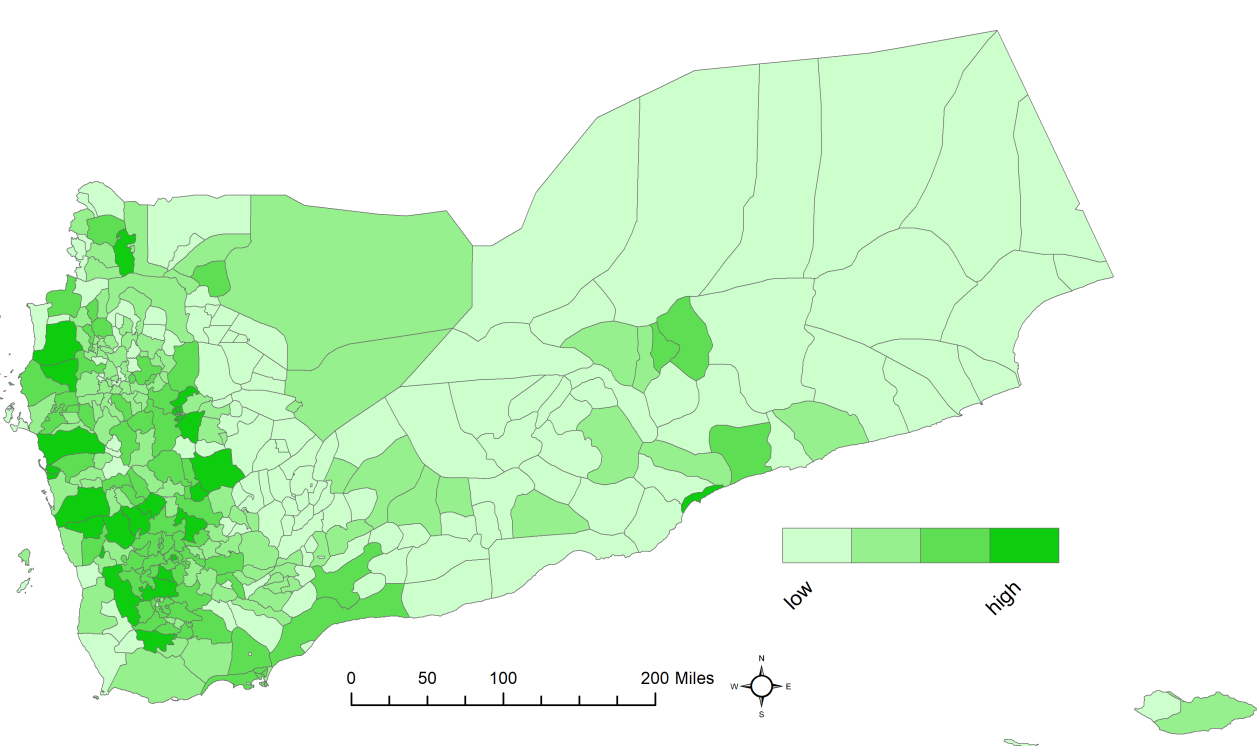
The vulnerability map shown in the left predict a high cholera risk in the western coast of Yemen, stretching from Al luhayya to Dhubab. When the vulnerability map is contrasted with the actual cholera attack map, it shows an overall overlap of the prediction to the actual attacks. The scatter plot on the left hand-side presents the correlation between the cholera vulnerability index and the actual cholera attacks, and visualizes a positive correlation between the two; Higher vulnerability levels seem to increase the number of cholera patients per 1000 persons. This result support the hypothesis that conflict-related factors have played a key role in the outbreak of cholera in Yemen.

### Implications for future research

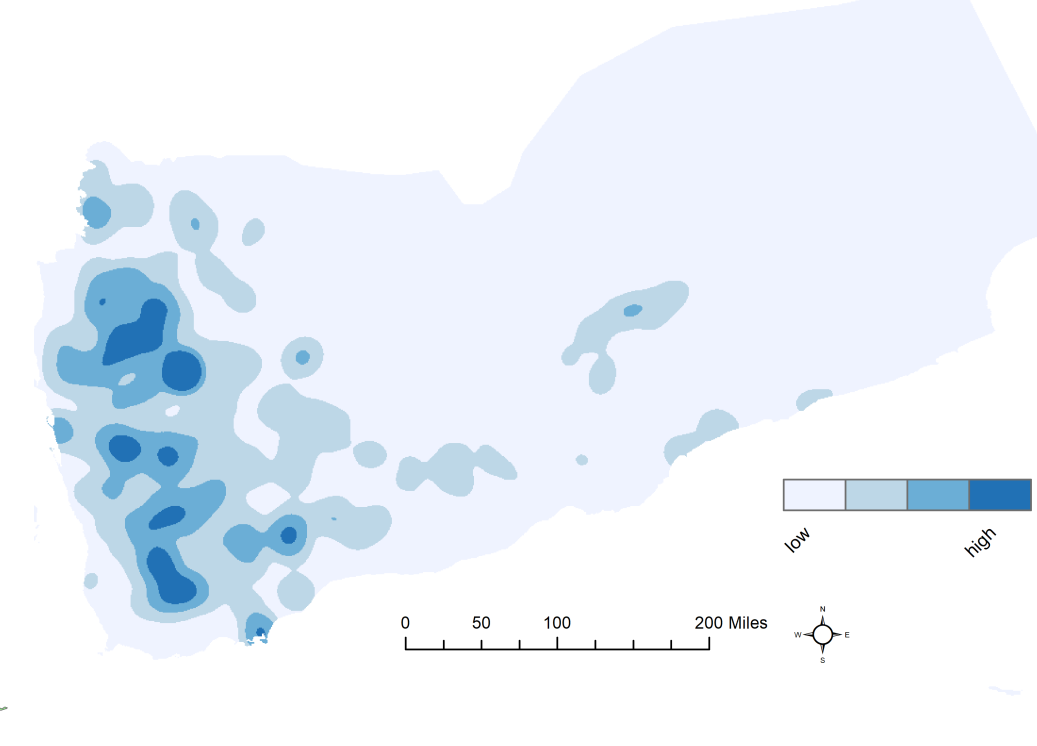
In addition to visualizing the conflict-induced nature of cholera in Yemen, the overall capability of this model in projecting cholera outbreak patterns suggest that the aforementioned factors could be considered in future models of cholera prediction in states affected by conflict. The map was not able to predict the outbreak in Sa'naa and its surrounding areas where the first cases of cholera originated, but this limitation is partly due to the fact that initial hits of cholera could consist of many different random factors which are not amenable to systematic analysis. However, once the initial hit spreads out geographically, the Yemeni model was able to predict the areas that are most vulnerable to the outbreak.

## Risk Factor Maps

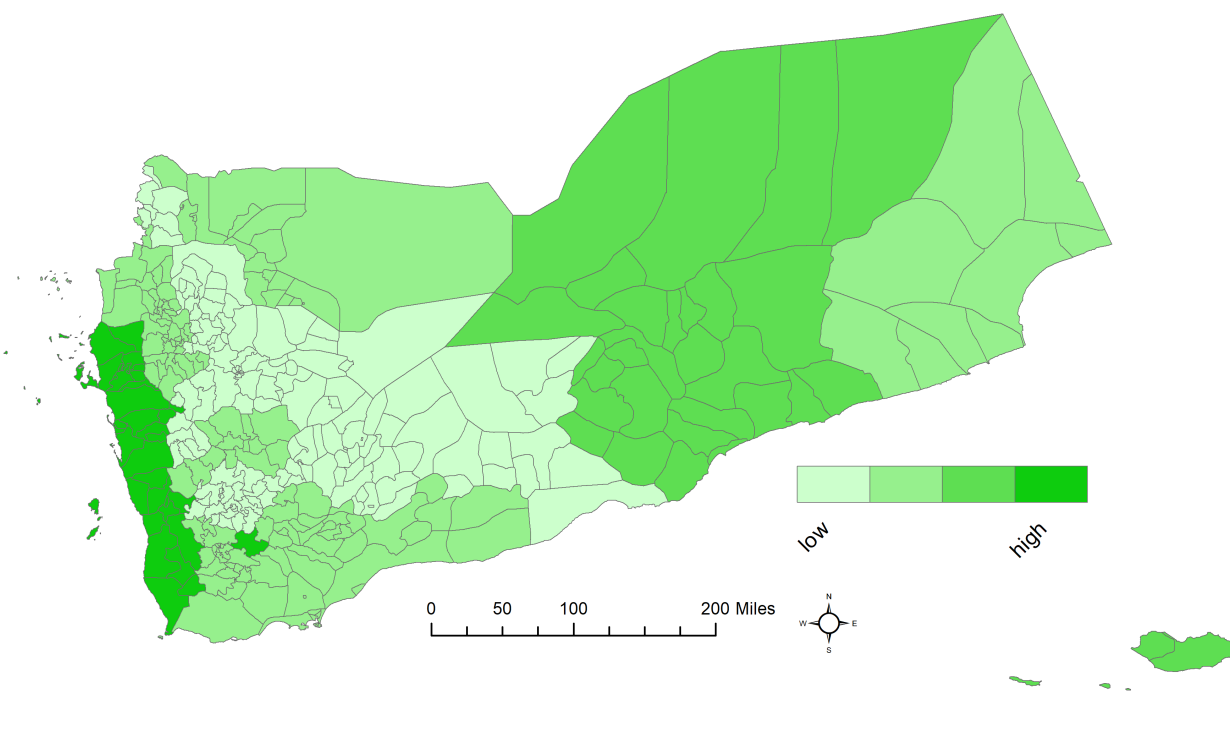
Population Density



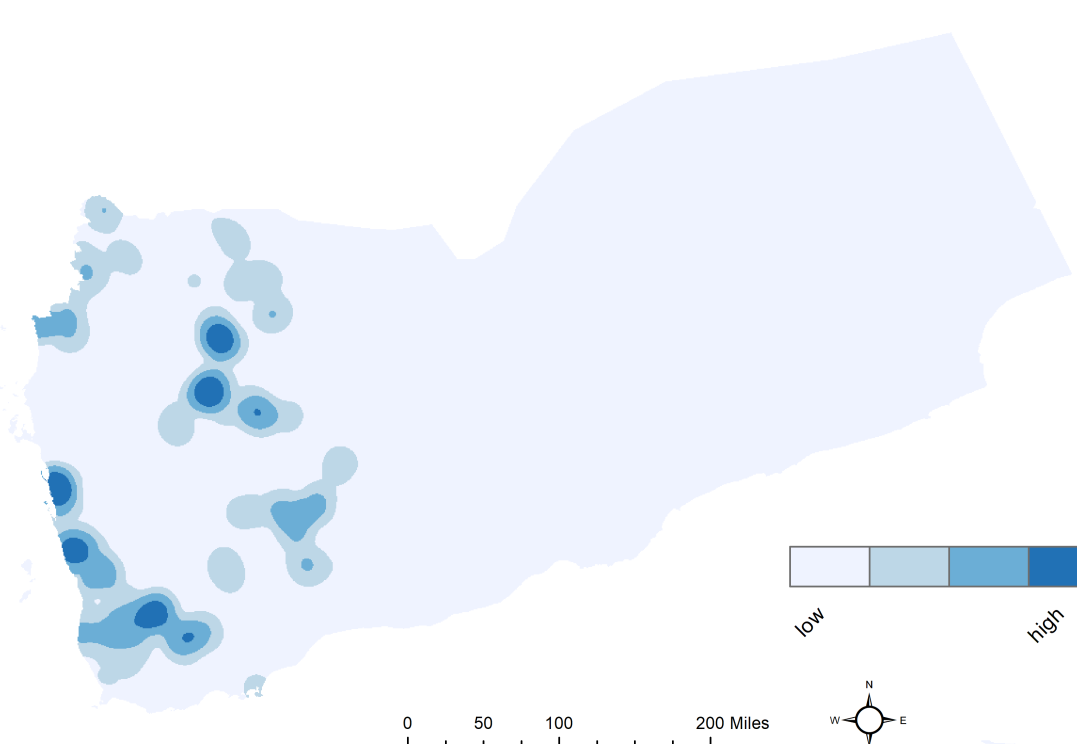
Hospital Density



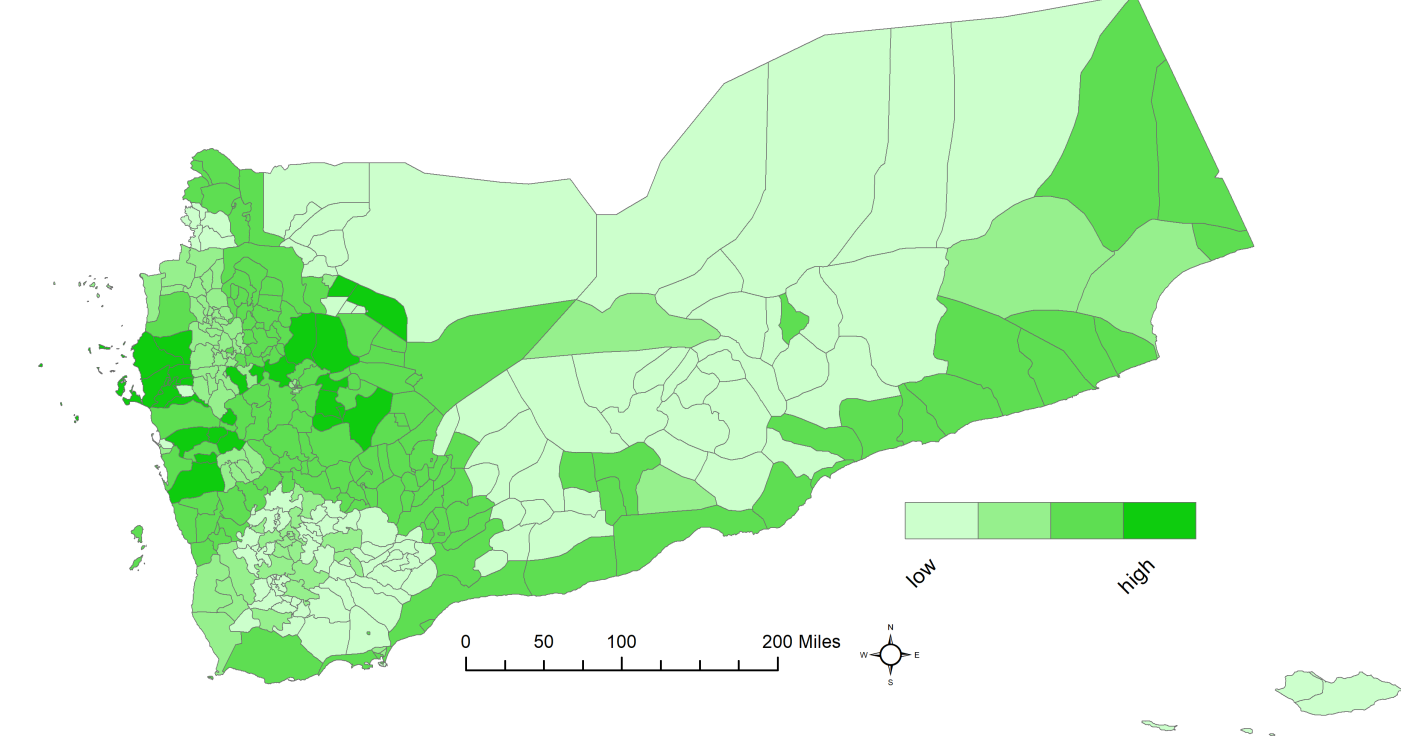
Malnutrition Levels



Conflict Intensity



Refugee Inflows



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**Data and Sources:** Yemen Ministry of Local Administration and Central Statistical Organization, OCHA Yemen, Global Health sites Mapping Project, Armed Conflict Location & Event Data Project, World Health Organization, Global GIS

Ali, Mohammad, et al. "Identifying environmental risk factors for endemic cholera: a raster GIS approach." *Health & place* 8.3 (2002)

Kandeh, Joseph, and Lalit Kumar. "Developing a relative ranking of social vulnerability of governorates of Yemen to Humanitarian crisis." *ISPRS International Journal of Geo-Information* 4.4 (2015)

Dureab, Fekri Ali, et al. "Yemen: Cholera outbreak and the ongoing armed conflict." *The Journal of Infection in Developing Countries* 12.05 (2018): 397-403.

**Spatial Reference Information:** WGS\_1984\_UTM\_Zone\_38N, Datum: GCS\_WGS\_1984