Geospatial and temporal patterns of annual cholera outbreaks in Matlab, Bangladesh

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Background – Cholera is a waterborne diarrheal disease endemic to Bangladesh, resulting in 1 million diagnoses annually. Such disease burden results in incalculable lost wages and treatment expenses, taken from the pockets of an already impoverished society. Two seasonally correlated outbreaks of cholera occur in Bangladesh every year. In the spring and early summer, the Bay of Bengal – which serves as a natural reservoir for the cholera bacteria – flows inland, causing the first outbreak amongst communities closest to the coast. Waste containing the cholera bacteria enters the sewage system and remains untreated due to poor water and sanitation infrastructure. Therefore, during the subsequent monsoon season, flooding of cholera-contaminated sewage into drinking water sources results in a second outbreak that extends further in from the coast than the first. Though considered common knowledge among local populations, this geographic and temporal progression has not been empirically verified in the current literature. The aim of our ongoing study is to systematically analyze the seasonal trajectory of endemic cholera in Bangladesh. Here, we discuss results from our pilot project in the near-coastal community of Matlab, Bangladesh.

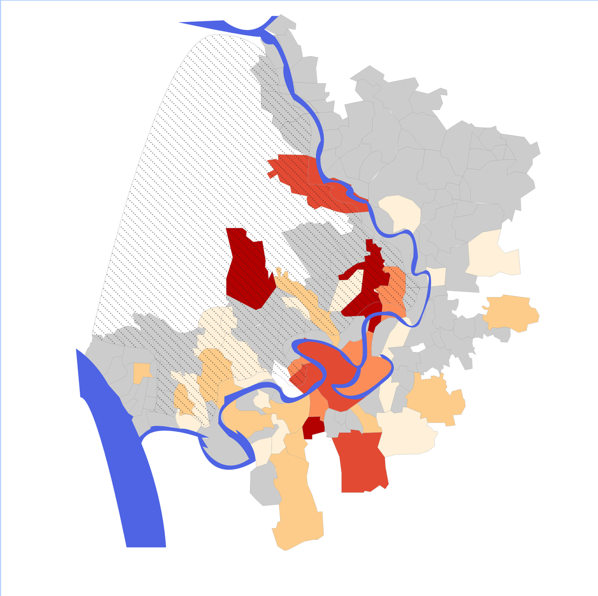


Figure 1. January, n = 83

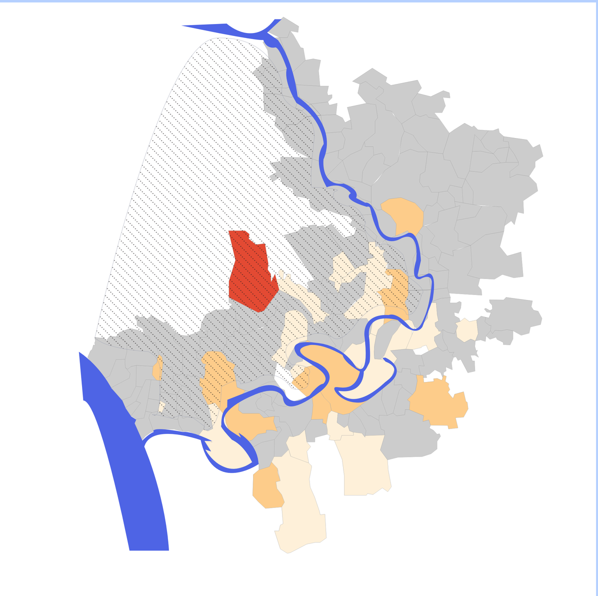


Figure 2. February, n = 34

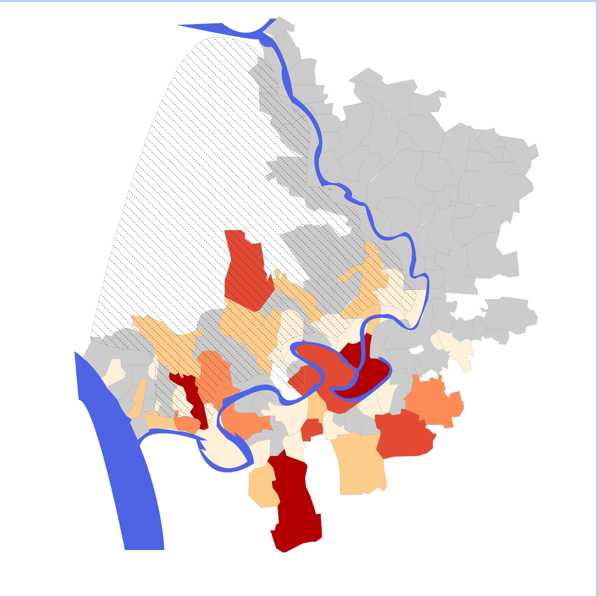


Figure 3. March, n = 89

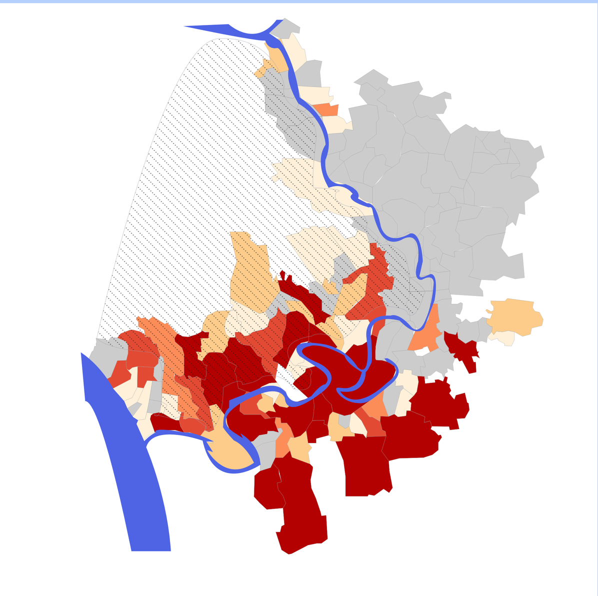


Figure 4. April, n = 267

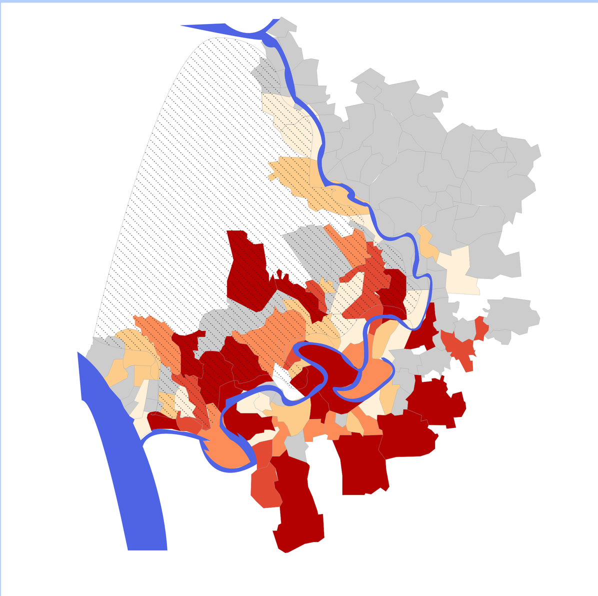


Figure 5. May, n = 217

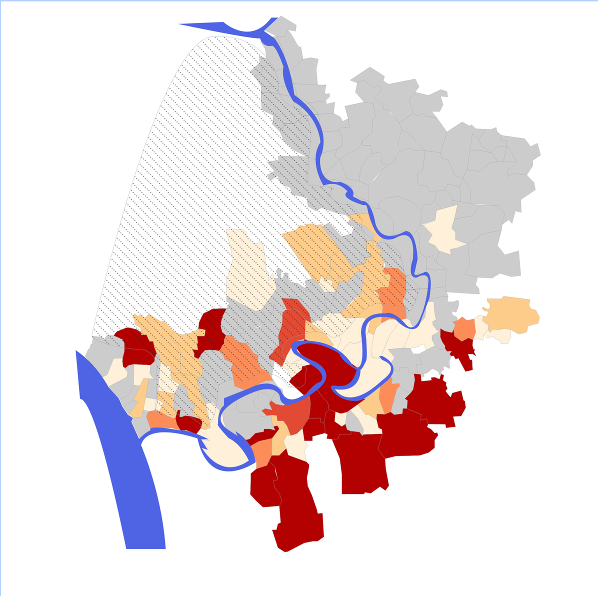


Figure 6. June, n = 165

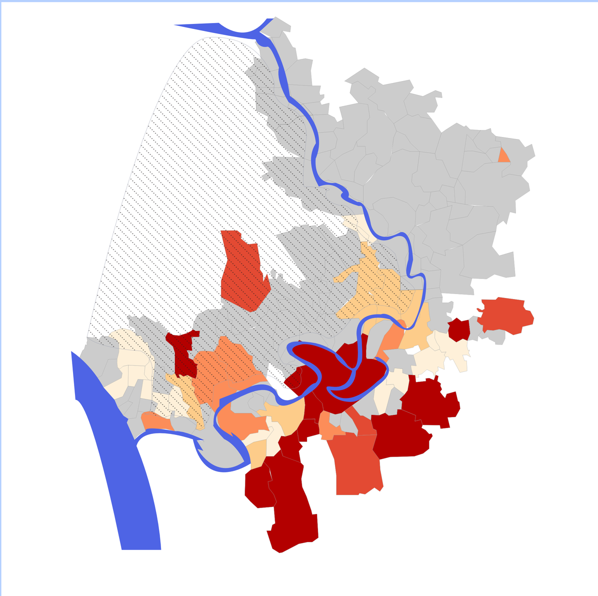


Figure 7. July, n = 139

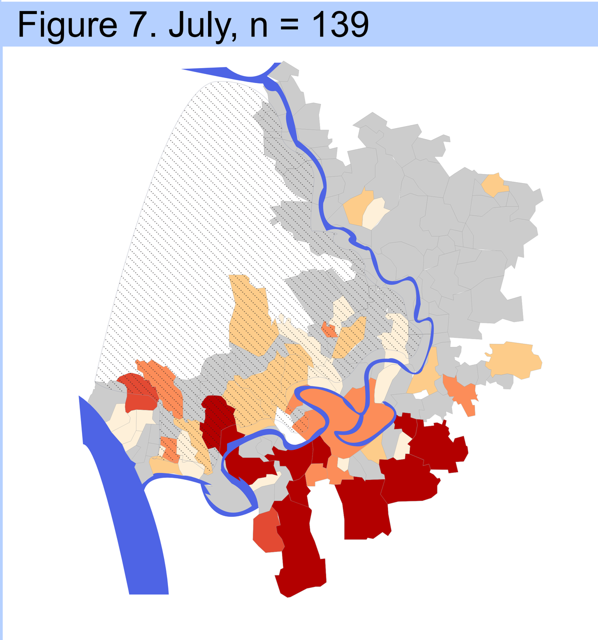


Figure 8. August, n = 132

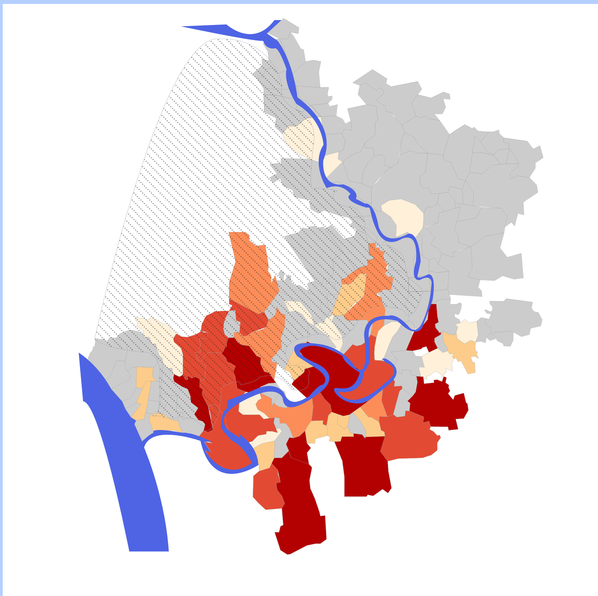


Figure 9. September, n = 170

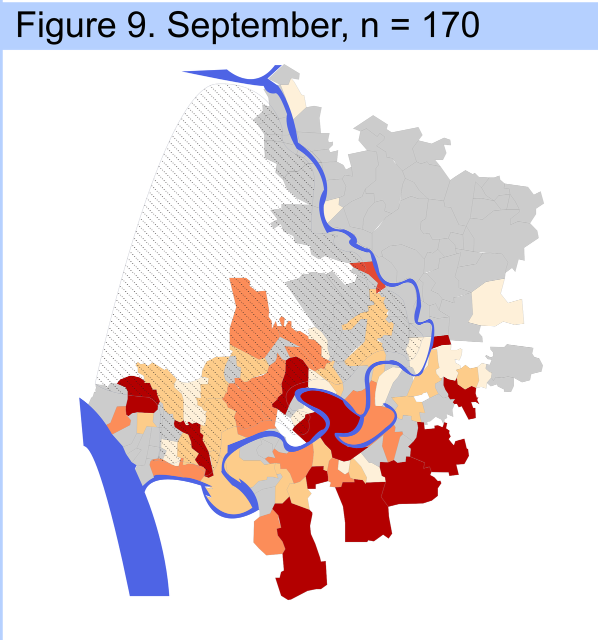


Figure 10. October, n = 170

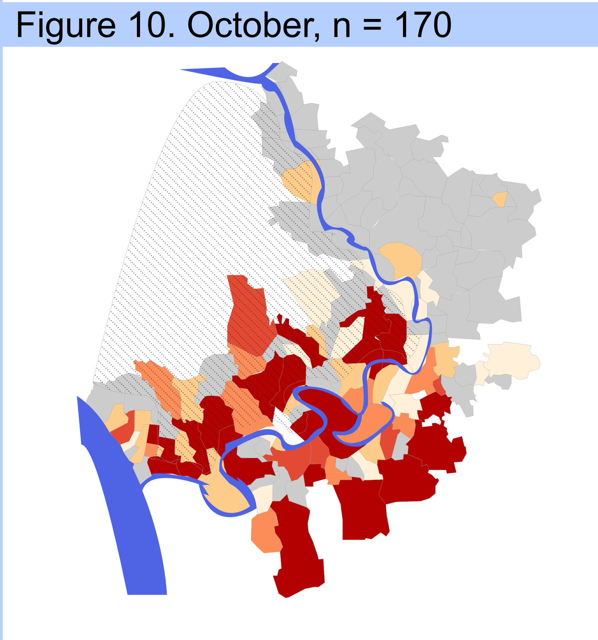


Figure 11. November, n = 227

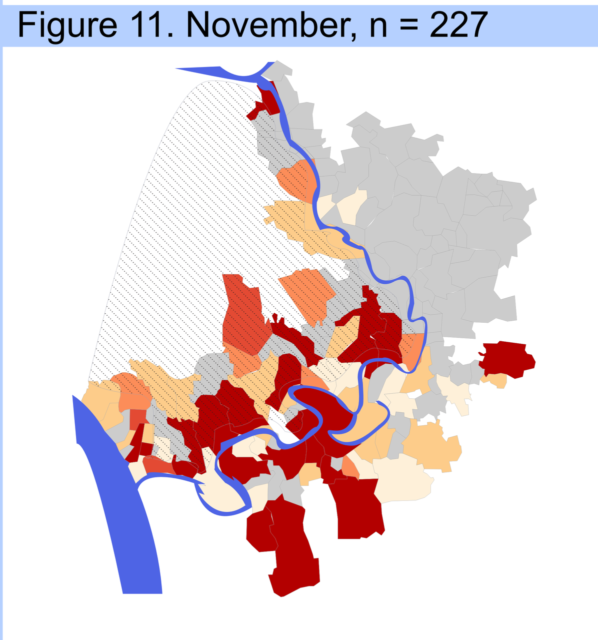
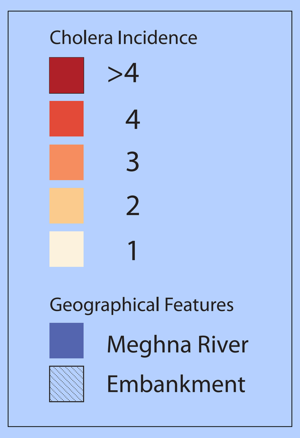


Figure 12. December, n = 213



Methods

The initial visualizations presented here use cholera data from hospital surveys conducted by the International Centre of Diarrheal Disease Research, Bangladesh (ICDDR,B) in Matlab *thana*. Only positively diagnosed cholera patients who sought care at the ICDDR,B clinic were included in the analysis. Each case in the dataset is referenced with a code that represents the patient's village of residence. Matlab *thana* consists of 142 villages. A shapefile of Matlab that incorporates the parameters of each village was created. Monthly aggregate cases per village were then plotted against the shapefile to demonstrate cholera proliferation in time and space (Figures 1-12). Daily aggregate cases were also plotted and animated to mimic the fine-scale spread of cholera over the course of a year. The simulation may be accessed by scanning the QR code to the left.

Results

Preliminary patterns suggest that villages close in proximity to the base of the Meghna River experience the majority of the area's cholera outbreaks and that incidence in the region is highest in late spring and late fall. Incidence is lowest from January to March and highest between April and May. Cases taper, reaching a lull between July and August; then, incidence picks up again, peaking again between November and December. April/May and November/December represent 25% and 23% of total annual case counts respectively (Figures 1-12). Spring incidence is heavily concentrated near the mouth of the Meghna River. Villages further from the Meghna demonstrate 57% higher relative prevalence in fall than in the spring. Overall, cholera incidence is more widely dispersed in the region during the second outbreak than in the first.

Discussion

Given that the monsoon season in this region takes place from June through October, our findings are consistent with local beliefs. Due to hydroclimatic drivers, bacteria-rich water inundates villages closer to the coast in April and May. Incidence lessens during the monsoon season because rainstorms disrupt the bacteria's ability to survive and reproduce. After floodwaters have stilled, bacteria are able to effectively multiply, achieving the quantities necessary to confer cholera in those who drink from contaminated water sources. During this post-Monsoon period, individuals also continue to contract cholera from naturally occurring bacteria in the Meghna River. Because of this duality, cases are more geographically diffuse in November and December than in the spring.

Conclusion

Our initial results demonstrate great promise in advancing our present knowledge of endemic cholera in Bangladesh. By improving our understanding of cholera proliferating in time and space, disease mitigation resources can be distributed to the most susceptible areas when they need them most. The next step forward for our ongoing study involves the use of mobile health (mHealth) case surveillance and cloud computing for real-time geographic and temporal cholera data acquisition.

Acknowledgements

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