In Response

Dear Sir:

The objective of our manuscript was to present an alternate hypothesis on large-scale climatic controls on epidemic cholera. Within this context data from Indus River Valley and Haiti were used to show that episodes of warm air temperature, followed by high rainfall may contribute to cholera occurrence. It appears that Gaudart and colleagues are not interpreting our results correctly.[1] We did not challenge the idea of importation, but rather disagree on the timing of such an event. Climate can play a role in a primary cholera outbreak. Spread of the disease within a population is a secondary route of transmission. Regarding references in our manuscript, we have provided all necessary and appropriate references within the context of our results and interpretations (such as Chin and others, 2011).[2]

We now present evidence, indicating our disagreement with the interpretation by Gaudart and colleagues.

1. Figure 7B presents climatological information on the pattern of rainfall in Haiti. For climatological studies, the accepted norm for establishing the average is a minimum of 30 years (FAO-Understanding climate variability and change-Module 1: ftp://ftp.fao.org/docrep/fao/010/a1247e/a1247e02.pdf). Because satellite data are not available for the full 30 years, we used precipitation data over Haiti from 1948 to 2011, which are available from the National Oceanic Atmospheric Administration PRECL-reanalysis database (we have also provided the database online in a spreadsheet format). We do not see any issues with the accuracy of Figure 7B based on the PRECL database. The interesting observation is that analysis by Gaudart and colleagues actually reinforces our findings since even on a 10 year average, from the TRMM database (Figure 1 in their letter), the month of September, 2010, had above average precipitation, supporting our hypothesis.

2. The absolute magnitude of any climatic process and, therefore the data will have errors associated with it. For example, the total precipitation from TRMM sensors and PRECL are expected to be different, because the algorithms used to estimate precipitation are not the same. It is critical to understand that TRMM is available from hourly to daily scales, whereas PRECL is available on monthly scales. The important point is the departure from mean (in other words, less or more than the long-term average). Figure 1 in Gaudart's letter, in fact, shows that, on average, September 2010 rainfall had a positive departure from the previous 10 years of average precipitation. This not only re-validates our analysis and conclusions but provides us with even more confidence that a second data source (TRMM) also shows trends that were observed in the PRECL database. Hence, we do not agree with their claim "which fails to indicate excessive rainfall during the 30-day period preceding epidemic onset (page 2; line 39)", when their own analysis shows that September 2010 precipitation was more than the climatological average.

3. The source of air temperature data was cited in our manuscript. "Haiti experienced above average warm air temperatures, in Figure 7A (representing 50 years of average air temperatures over Haiti taken from the National Oceanic and Atmospheric Administration [NOAA] reanalysis data). The data analysis shows that air temperature in the year 2010 was one standard deviation higher than the long-term average."

4. We would like to refer Gaudart and colleagues to a manuscript regarding the concept of standard deviation in climate science.[3] We mentioned that air temperature is one standard deviation higher than the long term average. The high (or low) of any climatic process is measured in terms of standard deviation by climate scientists.

5. The comparison of genomes, as well as its discussion, was not within the scope of our manuscript. Our parallel study provides insights on this.[4] Interestingly, Gaudart and colleagues cited other reports without mentioning the responses to those letters, where many aspects were clarified.[5] We refer Gaudart and colleagues to those manuscripts. Moreover, a recent case of cholera (http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=20572) was reported in Italy. A person who travelled for a vacation to Cuba was confirmed with cholera after returning to Italy. This case and several others are intriguing since they pose two important questions: (i) how could the cholera bacteria be present in Cuba and (ii) when the cholera victim returned to Italy, why there wasn't there an outbreak of cholera? The answers are that cholera bacteria are either naturally present in the environment, as has been documented for other parts of the world over forty years in hundreds of publications, or become endemic after introduction, but thereafter epidemic only during particular seasons of the year in countries with poor sanitation and lack of safe drinking water. We acknowledge that diseases can be transmitted by human travel from one place to another, but conducive environmental and climatic conditions play a significant role in epidemics in developing countries, as has been documented in many publications to date.

ANTARPREET JUTLA
Department of Civil and Environmental Engineering,
West Virginia University, Morgantown,
WV, USA

ELIZABETH WHITCOMBE
NUR HASAN
BRADD HALEY
ANWAR HUQ
Maryland Pathogen Research Institute,
University of Maryland,
College Park, MD, USA

ALI AKANDA
Department of Civil and Environmental Engineering,
University of Rhode Island,
Kingston, RI, USA

MUNIR ALAM
International Center for Diarrhoeal Disease Research,
Dhaka, Bangladesh

BRADLEY SACK
Bloomberg School of Public Health, Johns Hopkins University,
Baltimore, MD, USA

RITA COLWELL
Maryland Pathogen Research Institute,
  University of Maryland, College Park,
  MD, USA
Center for Bioinformatics and Computational Biology,
  University of Maryland,
  College Park, MD, USA
Bloomberg School of Public Health,
  Johns Hopkins University,
  Baltimore, MD, USA

REFERENCES

1. Gaudart J, Piarroux M, Moore S, Rebaudet S, Piarroux R, Barrais R, Boncy J, 2013. Environmental factors influencing epidemic cholera. *Am J Trop Med Hyg 89:* 1228–1230.
2. Chin C, Sorenson J, Harris JB, Robins WP, Charles RC, Jean-Charles RR, Bullard J, Webster DR, Kasarskis A, Peluso P, Paxinos EE, Yamaichi Y, Calderwood SB, Mekalanos JJ, Schadt EE, Waldor MK, 2011. The origin of the Haitian cholera outbreak strain. *N Engl J Med 364:* 33–42.
3. Hansen J, Sato M, Ruedy R, 2012. Perception of climate change. *Proc Natl Acad Sci. 109:* E2415–E2423.
4. Hasan NA, Choi S, Eppinger M, Clark PW, Chen A, Alam M, Haley BJ, Taviani E, Hine H, Su Q, Tallon LJ, Prosper JB, Furth K, Hoq MM, Li H, Fraser-Liggett C, Cravioto A, Huq A, Ravel J, Cebula T, Colwell RR, 2012. Genomic diversity of 2010 Haitian cholera outbreak strains. *Proc Natl Acad Sci 109:* E2010–E2017.
5. Hasan NA, Choi SY, Alam M, Cravioto A, Huq A, Cebula TA, Colwell RR, 2012. Reply to Frerichs et al.: Chasing the genetic diversity, not source attribution. *Proc Natl Acad Sci 109:* E3209.