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IMPACT OF CLIMATE CHANGE ON THE OCCURRENCE OF CHOLERA IN KATHMANDU, NEPAL

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ABSTRACT
Traditionally, cholera has been viewed as a strictly faecal-oral infection but recently increased attention is being paid to the environmental determinants of the disease. Therefore, this retrospective study was conducted to assess the impact of climatic factors - temperature, water precipitation and relative humidity on the occurrence/outbreak of cholera from 2008 to 2014 in Kathmandu district, Nepal. The monthly number of cholera cases was obtained from District Public Health Office, Kathmandu and meteorological data from Department of Hydrology and Meteorology, Nepal. The obtained data was entered into Microsoft Office Excel 2007 in a standard format and transferred into Statistical Package for Social Sciences 21.0. Time series analysis was done by using autoregressive integrated moving average (ARIMA) model. The yearly distribution of cholera cases in Kathmandu district showed an increasing trend from 2008 onwards and reached a peak in 2010 after which the number of cases follow a decreasing trend. The disease seems to be endemic in the district and cases appear throughout the year with seasonal rise in cholera cases starting from July. Temperature (maximum and minimum), rainfall and average relative humidity didn't show any positive correlations with number of cholera cases. Further studies on impact of climate change on cholera should be done dealing with data on daily basis and for a period of longer duration.

KEYWORDS: Climate change, Cholera, Kathmandu.

INTRODUCTION
Climate change is a significant and emerging threat to public health. WHO has identified cholera and other diarrhoeal diseases as one of the major health consequences of climate change. Waterborne diseases emerge after the too much or too little water.[1] Both scarcities of water, that is essential for hygiene and excess water mainly floods contributing to the spread of contaminated water will increase the burden of diarrhoeal disease. Globally, there are an estimated 3-5 million cholera cases and 100,000-120,000 deaths due to cholera each year. Several studies have shown the occurrence of cholera in Nepal[2-9] and 26 districts have been categorized by the Epidemiology and Disease Control Division, Nepal as high risk outbreak prone districts, expecting 1-3 diarrhoeal disease outbreaks per year.[10] Traditionally, cholera has been viewed as a strictly faecal-oral infection but recently increased attention is being paid to the environmental determinants of the disease.[11] Evidences suggest that climate change contributes to increased morbidity and mortality in many regions of the world.[12] Therefore, it is of interest to anticipate the potential impact of extreme climate events such as abnormally hot temperatures, floods, etc on cholera. Changes in the number of *Vibrio cholerae* reservoirs could lead to changes in the number of this organism in the environment. Thus, climatic and/or environmental changes can potentially be responsible for the emergence of cholera in human populations.

MATERIALS AND METHODS
Study design
This retrospective study was done using secondary data analysis. The study design was descriptive longitudinal study from 2008 to 2014 for a period of 7 years.

Study population, sample size and selection criteria
The Kathmandu district, central region of Nepal, was selected as the study site. Diarrhoeal diseases including cholera are prevalent in this district. All cases of cholera reported by District Public Health Office (DPHO) of Kathmandu district were included in the analysis.

Data collection procedures and instruments
Epidemiological data on cholera were accessed in April 2016 from the DPHO, Kathmandu. Similarly, monthly data on climate change i.e temperature (maximum and minimum), relative humidity and rainfall from the

meteorological station located at longitude 85.37292, latitude 27.70386 and elevation 1337 was accessed in March 2016 from Department of Hydrology and Meteorology (DHM), Kathmandu.

Data analysis

The obtained data was entered into Microsoft Office Excel 2007 in a standard format and transferred into Statistical Package for Social Sciences 21.0. Time series analysis was done by using autoregressive integrated moving average (ARIMA) model. Premonsoon (March-May), Monsoon (June-September), Postmonsoon (October-November) and winter (December previous year – February) were the four categorized seasons used.

RESULTS

The yearly distribution of cholera cases in Kathmandu district showed increasing trend from 2008 onwards and reached a peak in 2010 after which the number of cases follow a decreasing trend.

The disease seems to be endemic in the district and cases appear throughout the year with seasonal rise in cholera cases starting from July (Fig. 1).

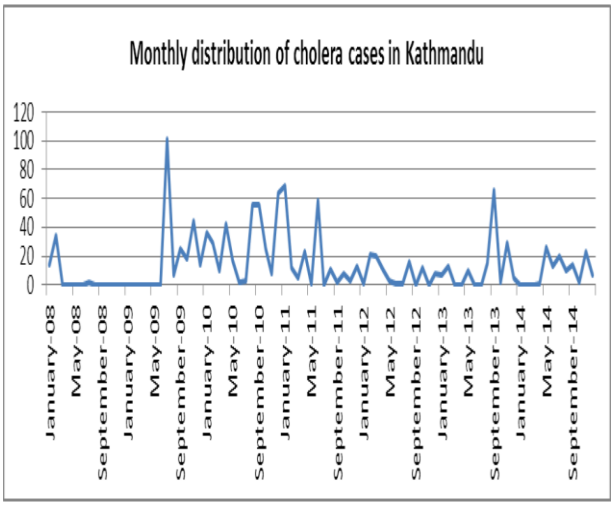

Fig:1. Monthly distribution of cholera cases in Kathmandu.

The number of cholera cases were highest during Monsoon followed by winter and about similar number of cases appeared during pre-monsoon and post-monsoon period.

Table 1: Seasonal variation of cholera cases

Season	Cholera cases
Pre- monsoon (March-May)	169
Monsoon (June-Sep)	479
Post-monsoon (Oct-Nov)	174
Winter (Dec-Feb)	347

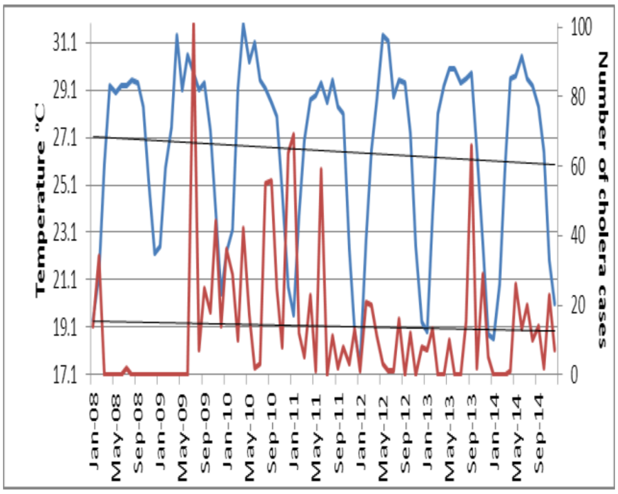

Fig: 2. Time plots of number of cholera cases per month and monthly maximum temperature (ºC) in Kathmandu, 2008—2014.

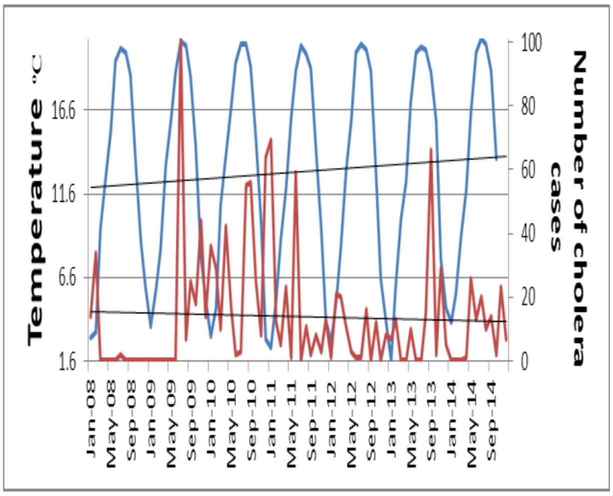

Fig: 3. Time plots of number of cholera cases per month and monthly minimum temperature (ºC) in Kathmandu, 2008—2014.

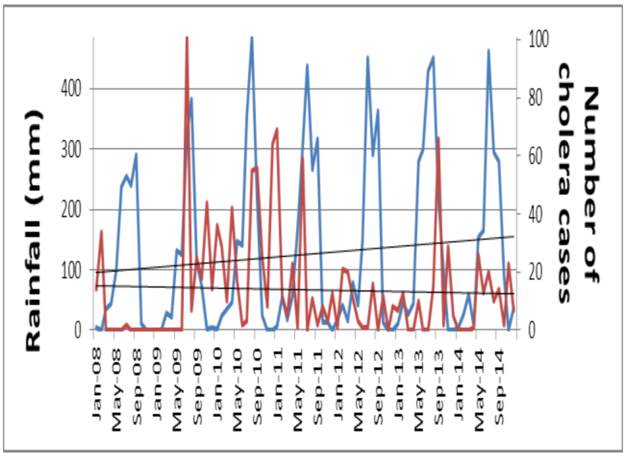

Fig: 4. Time plots of number of cholera cases per month and monthly rainfall (mm) in Kathmandu, 2008—2014.

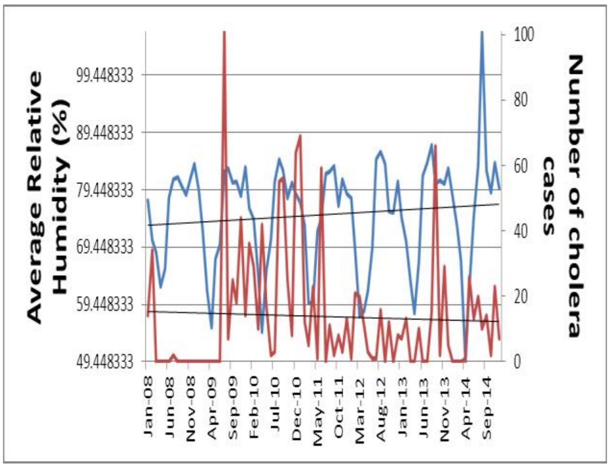

Fig: 5. Time plots of number of cholera cases per month and average relative humidity (%) in Kathmandu, 2008—2014.

Temperature (maximum and minimum), rainfall and average relative humidity have not shown positive correlations with cholera occurrence.

Table: 2. Correlation of Climatic variables with cholera

Climatic variable	Pearson correlation	p-value
Maximum temperature	-.045	.681
Minimum temperature	-.006	.975
Rainfall	.085	.441
Relative humidity (AM)	.058	.601
Relative humidity (PM)	.151	.171
Average relative humidity	.118	.284

DISCUSSION

Temperature, salinity, rainfall and plankton have proven to be important factors in the ecology of *V. cholerae*, influencing the transmission of the disease in those regions of the world where the human population relies on untreated water as a source of drinking water.[13]

Climatologists predict a 1.4 to 5.8°C rise in mean temperatures over the next 100 years.[14] Increasing temperatures would be expected to expand the range and increase the prevalence of *V. cholerae*. Changes in sunlight and/or UV intensity could increase the rates of induction and propagation of the CTXΦ phage and, thereby, increase the potential for the emergence of new toxigenic *V. cholerae* strains.[15]

Analysis of the frequency of specific disease cases throughout the year is a logical first-order assessment of the potential role of climate in disease transmission. For cholera, a distinct seasonal pattern is evident, particularly in regions of endemicity.[15] Our study showed that the disease is endemic in Kathmandu. Cholera is firmly endemic in some areas such as the South Asian countries - Bangladesh and India where cholera infections occur every year. Several additional studies describe the pattern of two annual El Tor cholera peaks: a smaller spring outbreak in April before the monsoons followed by a larger fall outbreak from September to December after the monsoon[19,20] In Pakistan, classical cholera typically increases from November to January and from April to May[21] while in Kolkata, India, seasonal patterns of cholera cases peak in April, May, and June.[22]

Torres, 2001 incorporated seasonality into a model of endemic cholera and showed that cholera infections occurred 2 to 4 months after the onset of *V. cholerae* growth in the environment.[23] Furthermore, only transient environmental reservoirs of *V. cholerae* were required to maintain endemism in poor communities. This organism can persist within a given geographical location for many years, offering an explanation of reappearance of cholera after years of quiescence or seeming absence.[24]

Other climatic variables related to water levels such as rainfall have also been involved to explain cholera patterns since early times. Floods and droughts can affect not only the concentration of the bacterium in the environment, but its survival through the effect of salinity, pH or nutrient concentrations, as well as human exposure to the pathogen, sanitary conditions and susceptibility to disease.[25] It is likely that high rainfall favor multiplication of the bacteria and contamination of water sources by the bacteria.[26] However, in this study, cholera shows an irregular trend with temperature and rainfall variability.

According to Huq et al. (2005), environmental sampling and analysis of the environmental and clinical data revealed significant correlations of water temperature, water depth, rainfall, conductivity, and copepod counts with the occurrence of cholera toxin producing bacteria.[27]

In the context of Nepal, only few studies[1, 28,29] have been documented regarding the association of climate change with cholera outbreak. Bhandari et al., 2012 concluded that the association among climate variables and diarrheal disease occurrence cannot be neglected and recommended further prospective longitudinal study adjusting influence of non-climatic factors. Gautam et al., 2012 reported a small cholera outbreak in winter season in Saptari district of eastern Nepal in 2007.[30]

The limitation of this study lies in the fact that time series analysis has been done based on data of 7 years. However, researchers suggest that the data of longer period at least 30 years should be analyzed to study the impact of climate change on human health.

CONCLUSIONS

The time series analysis showed that none of the climatic variables i.e maximum and minimum temperature, relative humidity and rainfall are significant predictors for cholera in Kathmandu, Nepal.

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