

Climate Change and Occurrence of Diarrheal Diseases: Evolving Facts from Nepal

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ABSTRACT

Background: Climate change is becoming huge threat to health especially for those from developing countries. Diarrhea as one of the major diseases linked with changing climate. This study has been carried out to assess the relationship between climatic variables, and diarrhea and to find out the range of non-climatic factors that can confound the relationship of climate change and human health.

Methods: It is a Retrospective study where data of past ten years relating to climate and disease (diarrhea) variable were analyzed. The study conducted trend analysis based on correlation. The climate related data were obtained from Department of Hydrology and Meteorology. Time Series analysis was also being conducted.

Results: The trend of number of yearly cases of diarrhea has been increasing from 1998 to 2001 after which the cases remain constant till 2006. The climate types in Jhapa vary from humid to per-humid based on the moisture index and Mega-thermal based on thermal efficiency. The mean annual temperature is increasing at an average of 0.04 °C/year with maximum temperature increasing faster than the minimum temperature. The annual total rainfall of Jhapa is decreasing at an average rate of -7.1 mm/year. Statistically significant correlation between diarrheal cases occurrence and temperature and rainfall has been observed. However, climate variables were not the significant predictors of diarrheal occurrence.

Conclusions: The association among climate variables and diarrheal disease occurrence cannot be neglected which has been showed by this study. Further prospective longitudinal study adjusting influence of non-climatic factors is recommended.

Keywords: climate change; diarrhea; Jhapa district; Nepal.

INTRODUCTION

Climate is regarded as Earth's atmospheric condition over a period of time. It includes pattern of precipitation, temperature, humidity and seasons. The recent burning issue of concern regarding climate is its changing phenomenon. There are handful of evidences that climate is changing and changing not for good. IPCC in 2007¹ reported United Nations that the Earth's climate system is undoubtedly getting warmer. While Climate change is there to influence and effect varied vulnerable

sectors, health of the people is the ultimate issue for such effect.

WHO has showed concern stating climate change as significant and emerging threat to Public Health. Particularly in developing countries, the health outcomes of climate change is predicted to be much higher due to their low coping and adapting capacity to climate change. With such concern, it is high time the health and climate change be linked to understand and decipher

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the appropriate interventions which could be applied in developing countries. This research was carried out with similar concerns and was one of the pioneer studies conducted in Nepal.

This study was carried out with the objective of discerning relationship between climatic variables (average maximum and minimum temperature, total rainfall and humidity) and diarrhea occurrence in Jhapa district of Nepal. It falls under sub-tropic zone where summer is very hot and winter is cool. Jhapa receives most of the rainfall during monsoon season in the summer and its hilly northern area receives more rainfall than that of the South. Diarrhea still is a major public health problem in Jhapa district of Nepal.²

Diarrhea has been stated as one of the most important health impacts linked with short-term and long-term climate changes.³ The climatic extreme events such as drought, flood, and landslides contribute to occurrence of diarrhea through contamination and shortage of proper drinking water especially to those hardship families. The rise in temperature act as a constituent in microbial growth in poorly dumped solid wastes at open places. This is further aggravated by rainfall which can be the medium for further transmission of microbial contamination which may lead to diarrhea.

METHODS

This was a retrospective study using secondary data of ten years period from the year 1999-2008. Health-related data on malaria were taken from the Health Management Information System of the Department of Health Services for the ten-year period. The obtained data were verified by visiting the Jhapa district and accessing the same information from District Public Health Office (DPHO) of Jhapa district. The inconsistent data were then discussed with statistical officer of DPHO and came into consensus after verifying from primary data collection sheet. As for the climate related data, they were obtained from the Department of Hydrology and Meteorology for the same period of time. The monthly record on maximum and minimum average temperature, total rainfall and morning and evening humidity were obtained.

In case of non-climatic data, access was difficult, lacking and in some cases incomplete as well. So, the non-climatic data due to its inappropriateness were not included in the analysis. The standard analysis of climate change and human health could not be done by holding non-climatic factors constant. Therefore, the analysis was done using time-series analysis and the test of significance was applied wherever applicable.

The data, then, was entered into MS Excel in a standard format and transferred into SPSS 13.0 (IBM Inc.). The analysis was done by calculating correlations and time series analysis (ARIMA).

RESULTS

Distribution of diarrheal diseases: The trend of number of yearly cases of diarrhea has been increasing from 1998 to 2001 after which the cases remain constant till 2006 (Figure 1). In the year 2007, the number of cases increased by about 20% from the previous year. The reason for this may be the occurrence of outbreak of diarrheal diseases in Jhapa district in the year 2007 with 900 cases and 6 deaths. The month wise distribution of diarrhea in the district further showed that the disease is endemic in the district with cases appearing throughout the year showing seasonal rise from March to November.

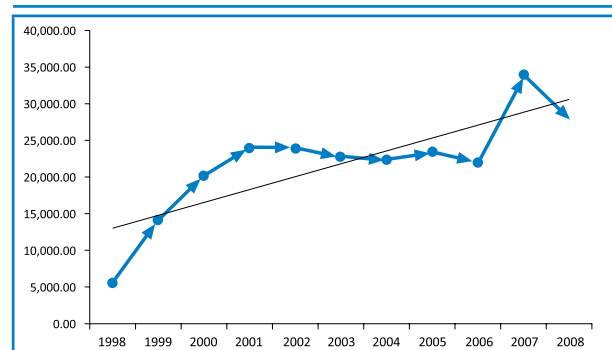


Figure 1. Total Reported Diarrhea cases in Jhapa (from 1998-2008)

Climate of Jhapa: A study carried out by Department of Hydrology and Meteorology on climatic classification of Nepal by Thornthwaite method shows that the climate types in Jhapa varies from humid to per-humid based on the moisture index and Mega-thermal based on thermal efficiency. For the current study temperature, rainfall and humidity data have been used. Altogether 5 stations with sufficient number of years of data are available. The description of the stations with their location is shown in figure 2.

Temperature Change: Temperature of Jhapa gradually increases from being lowest in the beginning of the year. Temperature then peaks to the highest which is usually over 30 °C just before monsoon arrives in the region and it starts to decrease from the month of August. Season wise, monsoon is the warmest season (28.1 °C), followed by pre-monsoon (25.5 °C) and post-monsoon (23.9 °C). Winter is the coldest season with 17.5 °C as the mean seasonal temperature. The highest ever recorded temperature in Jhapa was 42.5 °C in April 1992 and the lowest temperature was 1 °C in January 1987.

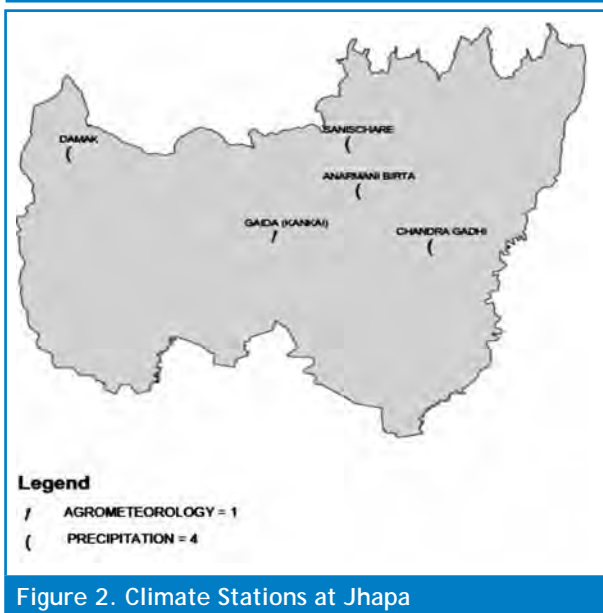


Figure 2. Climate Stations at Jhapa

The study by DHM showed that the mean annual temperature is increasing at an average of 0.04 °C/year (Figure 3) which is similar to Nepal’s average increasing temperature. However, average maximum temperature is warming much faster (0.06°C/year) than the minimum temperature (0.01°C/year). Moreover, compared to other seasons the average maximum temperature during monsoon (summer) season is increasing quite rapidly at 0.72 °C/year and the average minimum temperature during winter season is increasing at 0.058°C/year. Due to such trends, the day time temperature is getting hotter during monsoon season and night time temperature is becoming warmer during the winter season.

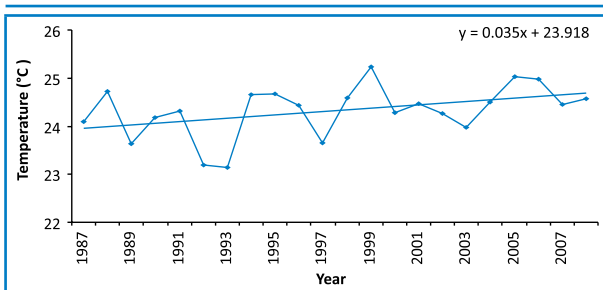


Figure 3. Mean Annual Temperature trend

Rainfall Change: There are mainly two rain bearing weather systems that affect Nepal, Monsoon during the four months of June to September and the "Western disturbances" especially during the winter. In case of Jhapa district, rainy monsoon contributes 2091.2 mm of rain which is about 82 per cent of the annual total rainfall with July being the wettest month (719mm) and December as the driest month (7 mm) of the year.

As per the general principle, the increase in temperature in Jhapa district must be conducive to

the increase in evapotranspiration bringing changes in atmospheric moisture content and precipitation pattern but surprisingly the annual total rainfall of Jhapa is decreasing at an average rate of -7.1 mm/year (Figure 4). Highest decrease in rainfall has been observed during Monsoon season (-12.6 mm/year).

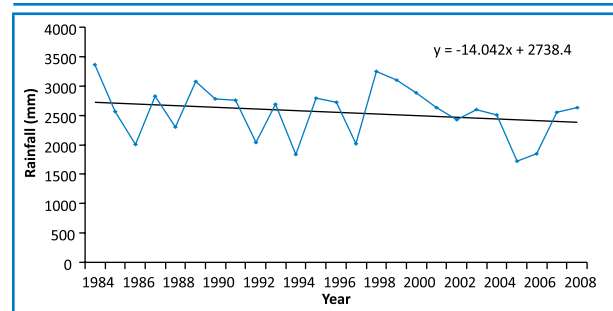


Figure 4. Mean Annual Rainfall trend

The difference in Coefficient of Variation of decadal mean season total rainfall between 1998-2008 and 1987-1997 showed that monsoon rainfall is getting unpredictable. The resultant affect has been on large inter annual variation in rainfall which can result to floods and droughts in the region. Hence, the plot of standardized rainfall anomaly of rainfall variation in Jhapa district shows that Jhapa had experienced more droughts (6 years) than flood (3 years) in the past (1985-2008) (Figure 5).

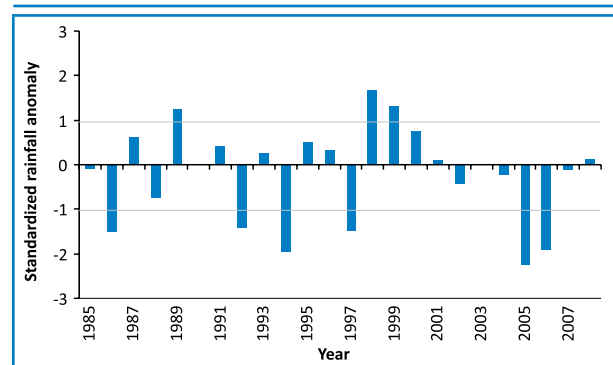


Figure 5. Inter Annual Variation in Rainfall

Relative Humidity: The relative humidity (RH) data is obtained twice daily, 8:45 AM and 5:45 PM of each day. Monthly average RH in Jhapa remains lowest during March and April in pre-monsoon season and highest during four months of monsoon.

The RH in Jhapa is increasing when two decades (1987-1997 and 1998-2008) are compared. The morning RH have increased ranging from 0.2 per cent in monsoon season to 3.8 per cent in winter whereas evening RH have increased ranging from 0.6 per cent in post-monsoon season to 3.2 per cent in pre-monsoon season except in winter season where evening RH has decreased.

Relation of climate change and diarrhea: The trend of climate variables of Jhapa district is worth concerning. With that, the endemicity of diarrheal disease can certainly aggravate the situation.

The constant increase in diarrhea cases has been observed in Jhapa with minimal changes in the minimum and maximum temperatures. The cases have also been observed to be increasing with increasing temperature. The highest cases of diarrhea are seen during months of high temperature. The correlation analysis also showed positive correlation of diarrhea with Maximum and Minimum Temperature which is statistically significant, though the strength of correlation is low. As there is no change in relative humidity, the diarrheal cases are observed to be increasing. On the contrary, inverse trend has been observed between total rainfall and diarrheal cases with former in decreasing trend and the latter in increasing trend. Rainfall and diarrhea has positive correlation which is significant as well (Table 1).

Table 1. Correlation among climate variables and Diarrheal cases

| Climate Variables | Pearson (p-value) |
|------------------------|-------------------|
| Maximum Temperature | .268 (.003) |
| Minimum Temperature | .263 (.004) |
| Relative Humidity (AM) | .079 (.394) |
| Relative Humidity (PM) | .033 (.722) |
| Rainfall | .230 (.011) |

On the other hand, when time series analysis was conducted, none of the climate variables (correlated and/or uncorrelated) were found to be the significant predictors for diarrheal occurrence.

DISCUSSION

The global burden of diarrhea is huge especially in developing countries.³⁻⁵ Total 78% of total diarrheal deaths occur only in WHO African and South-East Asian regions among the developing countries.⁶ With that, children of developing countries face as many as 12 episodes of diarrhea each year with 10-20% of time being ill from diarrhea in first three years of life.³ Along with such burden, diarrhea is also highly linked with long term and short term change in climate with frequency and intensity of occurrence of extreme climate events such as droughts, floods being responsible for such disease occurrence.

The diarrheal disease in Jhapa district has been increasing since 2006. The monthly distribution of diarrheal diseases showed an increase in the number of cases from April to September. The climatic condition of Jhapa district ranges from humid to per-humid with maximum temperature soaring mostly above 30 degrees in Celsius. The trend analysis showed the constant

increase in diarrhea cases in the district with minimal changes in average temperature and humidity. Although significantly correlated, temperature was not found to be the predictor for diarrheal occurrence in time series analysis. However, higher cases were observed during the period of high temperatures (Figure 6). Such high temperatures influence the growth of disease organisms in the environment.⁷⁻⁹ A time series study conducted in Peru and islands of Fiji estimated 8% and 3% increase in diarrhea admissions respectively with every 1 degree Celsius increase in temperature.^{10,11} Such evidences can infer high linkage of diarrheal cases occurrence with increase in temperature. However, it can't be ignored that increasing diarrhea cases in Jhapa district is also be related to non-climatic factors such as sanitation, hygiene, availability of health facilities, illiteracy and so on.

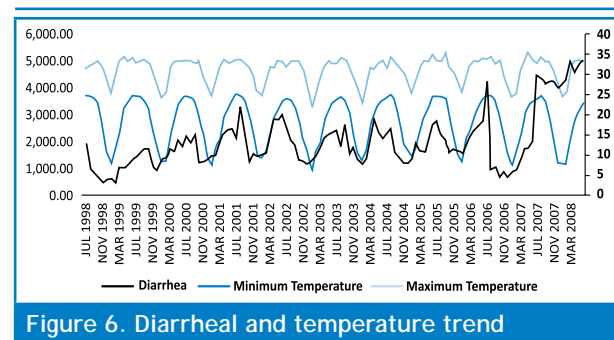


Figure 6. Diarrheal and temperature trend

On the contrary to diarrhea and temperature relationship, the rainfall pattern was observed to be in inverse occurrence with diarrheal cases in the district (Figure 7). With constant increase in diarrheal cases, decrease in total rainfall has been observed in ten years period. Such inverse relationship has also been observed in Pacific Islands where water availability and diarrheal cases were found to have inverse association.¹¹ With decreasing trend of total rainfall in Jhapa district, diarrheal cases may be influenced particularly due to adequate water unavailability. Similar to temperature, rainfall had significant correlation with diarrhea occurrence but was not found to be significant predictor of diarrhea occurrence. Studies have shown the association between heavy rainfall with occurrence of diarrheal cases especially in the outbreaks of cryptosporidium, giardia and other infections.¹²⁻¹⁶ Unusually low or high rainfall has been experienced in Jhapa district. However, the cases did not increase drastically during such years. The recent outbreak in Jhapa district was observed in the year 2007 where inter annual variation of rainfall was near to zero which meant that there was usual rainfall. Two consecutive years before 2007, drought was being observed but without any drastic change in diarrheal cases occurrence which contradicts the study

conducted in Peru which concluded that unusual high or low rainfall significantly increases diarrhea cases.¹⁰

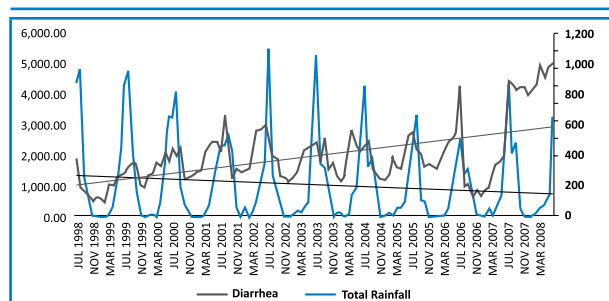


Figure 7. Trend of Diarrhea and Average rainfall

The non-climatic factors (such as socio-economic status, sanitation, hygiene status, literacy and so on) play vital role in occurrence of diarrheal cases. Their contribution in developing countries like Nepal is vital and their inclusion in the study is eminent. However, due to lack of proper reporting and recording of such variables, this study was unable to include them which can be deemed as the limitation of this study as well.

CONCLUSIONS

Diarrhea as a major public health problem of Nepal poses threat to huge proportion of population from all ages. Allowing it to be influenced by the consequences of climate change can be devastating for developing countries like Nepal. This study may have been shy of exactly indicating the occurrence of diarrheal cases due to climate change but has been successful in terms of successfully pioneering and piloting such research study, establishing the base for continuation of further similar studies in Nepal, and pointing out the probable problems that should be avoided if such studies are to be undertaken. Furthermore, the significant correlation among climate and disease variables suggests association between those elements including the fact that their association cannot be neglected. Therefore, It is recommended that a prospective longitudinal study be carried out in the three ecological regions of Nepal by including primary data for water, sanitation and disease control programme(s) as also the non-climatic variables like socio-cultural factors and other factors related to health system.

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