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Environmental Temperature, Cholera, and Acute Diarrhoea in Adults in Lima, Peru

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ABSTRACT

The effects of environmental temperature, presence and severity of El Niño, presence of cholera in the community, and interactions among these variables on the number of adult diarrhoeal patients attending the Hospital Nacional Cayetano Heredia in Lima, Peru, during 1991-1998, were evaluated. During 1991-1996, an increased number of visits to the hospital due to acute diarrhoea in the warmer months was observed. This periodic pattern was altered in 1997, when rising of the environmental temperature was observed in Lima secondarily associated with a strong El Niño event. A multivariate model was built in which environmental temperature and interaction between environmental temperature and presence of cholera predicted the number of adult patients with acute diarrhoea attending the Hospital Nacional Cayetano Heredia. Monitoring of environmental temperature and presence of cholera may be used as a warning system to predict epidemics of diarrhoea in adults, which may have a tremendous impact on healthcare strategies and management of health services in general.

***Key words*:** Diarrhoea, Acute; Cholera; Environment; Temperature; El Niño; Retrospective studies; Peru

INTRODUCTION

Climate change and climate variability significantly affect human health (1). The El Niño phenomenon, an example of climate variability, occurs every 3-7 years, affecting the climate globally, especially along the west coastline of South America, thereby increasing the occurrence of extreme weather events and leading to natural disasters (2-4). Natural disasters, causing disturbances in ecological systems and damage to public-health infrastructure, and related outbreaks of infectious diseases, particularly malaria and cholera, are among the recognized consequences of El Niño. Recent studies have shown a relationship between acute diarrhoea in children, including cholera, and the El Niño phenomenon (5,6). Several other factors might be implicated in determining the occurrence of diarrhoea in adults. Predicting epidemics of diarrhoea in adults may reduce both direct and indirect costs relating to these.

The purpose of this study was to explore the relationship among environmental temperature, occurrence and severity of El Niño, presence of cholera in the community, and number of adult diarrhoeal patients attending a public hospital in northern Lima, Peru, a city geographically located on the west coastline of South America.

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MATERIALS AND METHODS

A retrospective, observational and exploratory study was conducted at the Hospital Nacional Cayetano Heredia

(HNCH), Lima, a 375 in-bed teaching and referral hospital for about 3.2 million low- and medium-income people. Records of patients, aged over 13 years, with acute diarrhoea, defined as three or more stools per day for no more than three days, who were admitted to the Emergency Unit for oral and/or intravenous rehydration therapy during 1 January 1991–30 June 1998, were reviewed. Information on the aetiology of diarrhoea was not available from these records. The mean monthly environmental temperature in northern Lima was calculated using the mean daily temperatures obtained from three different daily measurements (at 07:00, 13:00, and 19:00 hours) recorded at three weather stations in northern Lima (National Meteorology and Hydrology Office). Two data sources were used for determining the presence of *Vibrio cholerae* in the community. Data on the occurrence of cholera for the 1991-1994 period were provided by the Peruvian General Office of Epidemiology which conducted regular surveys of cholera in the country. Information on cholera for the 1995-1998 period was taken from data of a surveillance system which had been implemented at HNCH. This surveillance system was aimed at identifying agents involved in acute diarrhoea in adults and their susceptibility to antimicrobial agents (7). The presence and severity of the El Niño phenomenon were determined according to data provided by the U.S. National Oceanic and Atmospheric Administration (U.S. Department of Commerce, http://www.noaa.gov). Thus, three weak short events (September 1991–March 1992, April-July 1993, and September-December 1994), and one unusual very strong long-lasting El Niño event (July 1997–June 1998) had affected the Peruvian coastline during the study period.

To predict the burden of acute diarrhoea in adults per month, a multiple regression analysis was performed. The number of acute diarrhoea cases (in a log-transformed scale) was the response variable. The mean monthly environmental temperature (in centigrade degrees), presence of cholera cases during the observation period, presence of a weak or strong El Niño phenomenon, and different interactions between these variables were entered into the model as independent variables. The presence of cholera and the severity of the El Niño event (weak or strong) were considered as dummy variables. A stepwise backward elimination procedure (p value entrance and removal criteria: 0.05 and 0.1 respectively) was used for fitting the final model.

RESULTS

During January 1991–June 1998, 237,382 adults attended the emergency room at HNCH, 40,020 (16.9%) of whom had acute diarrhoea. The number of adult cases of acute diarrhoea per month, mean environmental temperature of northern Lima, and occurrence of El Niño phenomenon during the study period are shown in Figure 1. The presence of the strong El Niño event of 1997-1998 changed the previously-observed pattern of acute diarrhoea cases. This led to an increase (47.5%) in the number of cases of acute diarrhoea observed during the second semester of 1997, contrasting sharply with an overall reduction of 62% for the same period, observed during the previous six years (1991-1996) ($p<0.0001$). The three weak and short-lasting El Niño events of 1991, 1993, and 1994 did not affect either the environmental temperature or the expected cases of acute diarrhoea during the study period (Fig. 1).

In the final model, the following variables correlated with the number of diarrhoea cases in adults (expressed in a log scale): mean monthly environmental temperature (ß=0.107, 95% confidence interval [CI] 0.063-0.150, $p<0.001$), presence of cholera in the community (ß=-1.031, 95% CI -2.099, -0.037, $p=0.058$), and the interaction between temperature and presence of cholera cases (ß=0.078, 95% CI 0.025-0.132, $p=0.005$). This model is robust enough to predict the response variable, as the independent variables explained about 70% ($R^2=0.702$) of the variance of the number of acute diarrhoea cases in adults (Fig. 2). If cholera was not present in the community, the model predicts a multiplicative increase of 11.3% (95% CI 6.5-16.2, $p<0.001$) of the number of adult diarrhoeal patients seen per month by each unit increase in the mean monthly temperature. In the presence of cholera, there is an additional multiplicative increase of 8.1% (95% CI 2.5-14.1, $p=0.005$) on the number of adult diarrhoeal patients seen per month by each unit increase in the mean monthly temperature.

DISCUSSION

Our study has shown that there was an increased number of visits due to acute diarrhoea in a public hospital in Lima during the warmer months over the 1991-1996 period. This periodic pattern was altered in 1997, when rising of the environmental temperature was observed in Lima, which was secondarily associated with a strong El Niño event which ensued that year. We propose a

Fig. 1. Number of diarrhoea cases in adults (vertical bars), mean environmental temperature of northern Lima (continuous line), and presence and severity of El Niño events (vertical lines indicate the beginning of El Niño) from January 1991 to June 1998

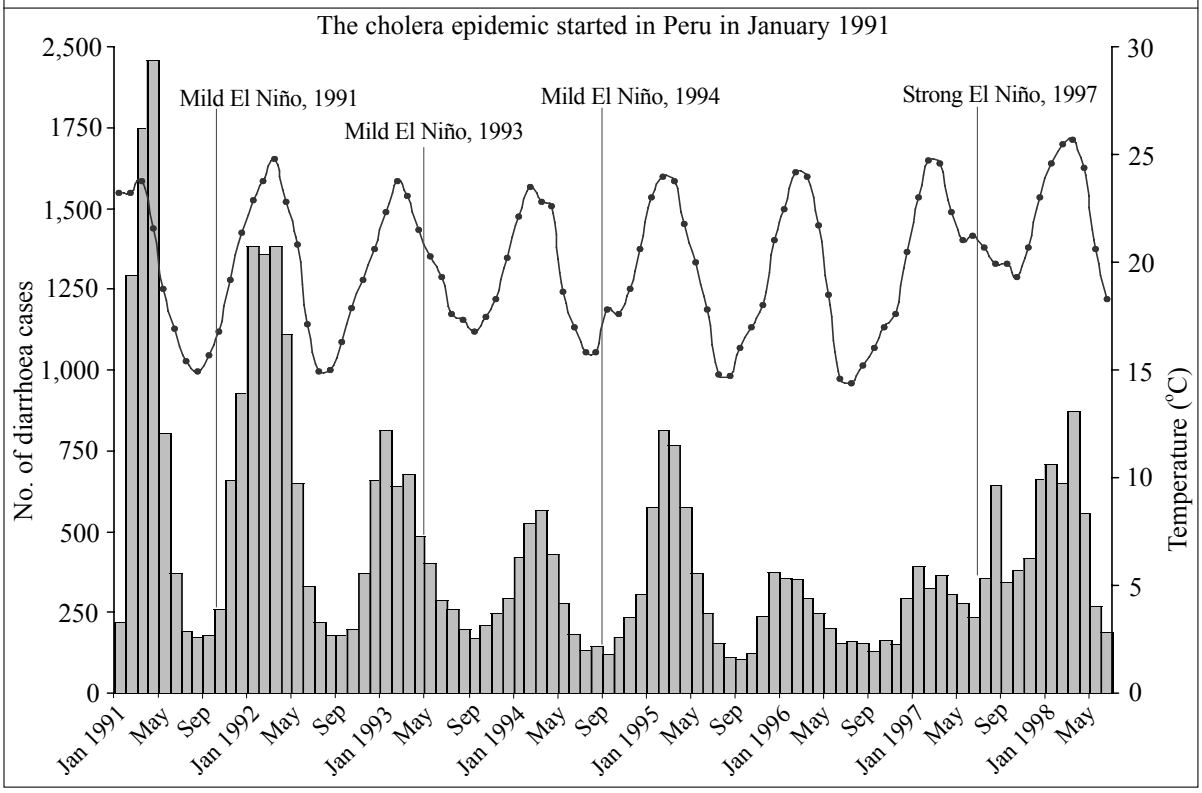
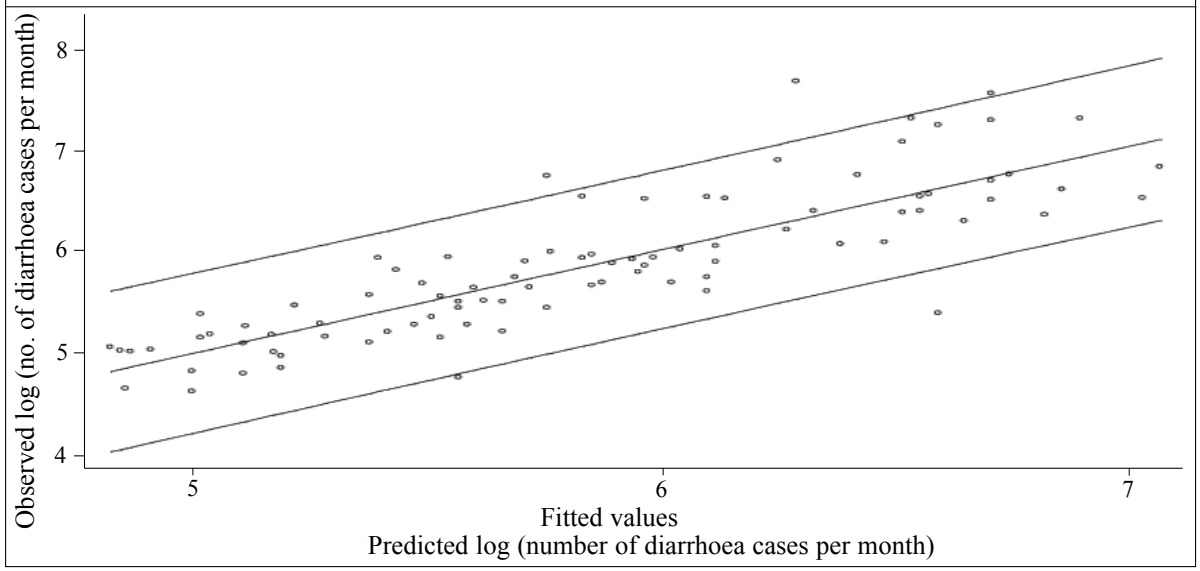


Fig. 2. Observed vs predicted values obtained after fitting the model: log (number of diarrhoea cases per month)=3.306+0.107 (mean monthly environmental temperature)-1.031 (presence of cholera in the community)+0.078 (mean monthly environmental temperature * presence of cholera in the community). R^2=0.702. Absolute and 95% confidence intervals of predicted values are shown



model that includes environmental temperature and interaction between this variable and the presence of cholera in the community, as independent factors to predict the number of acute diarrhoea cases in adults in a public reference hospital in north Lima. We could not find any association induced by the El Niño phenomenon and cholera themselves. The absence of significant effects induced by these variables may be explained in part because the period in which we evaluated these potential associations was too short compared to recently-conducted larger studies (8-10). Additionally, no data after the strong El Niño event of 1997-1998 were available for analysis. However, our study provides information about how certain determinants of diarrhoea in adults may be included in a model to predict cases of diarrhoea, which has not been the focus of recent research.

To consider the proposed model for further predictions, certain limitations of our study need to be taken into consideration. The accuracy of the model might have been influenced by the nature and quality of our retrospective data, in particular, by the different sources used for determining the presence of cholera in the community. Data on acute diarrhoea in adults were obtained from the Emergency Room of a tertiary hospital (HNCH), which obviously does not represent all cases of diarrhoea seen in the community. Cases of diarrhoea seen in a referral hospital may be influenced by different factors associated with patients, including but not limited to: advanced age, socioeconomic status, proximity to the hospital, education level, severity of dehydration, germ virulence, and co-morbid conditions. The potential influence of small diarrhoea outbreaks—not necessarily relating to *V. cholerae* but to other intestinal pathogens—in the burden of diarrhoeal patients was not assessed either. These outbreaks may alter the expected patterns of occurrence of diarrhoea and might not always be linked to the variables evaluated to fit our model. Further studies evaluating these variables are warranted. Furthermore, after the first cholera epidemic in our country in 1991 and as a result of health-promotion activities, people have learnt how to prevent acute diarrhoea, which could explain, in part, the progressive decline in the number of cases seen at the referral hospital over that time.

The association between diarrhoeal diseases and environmental temperature is a well-recognized phenomenon. In countries endemic for cholera, outbreaks are seen during the warm seasons of the year. Bangladesh, for instance, has more than one outbreak of cholera every year (11). These predictable patterns of association between certain infections, especially water and vector-borne diseases (3), and climate conditions are, however, drastically affected when significant environmental changes take place regionally or globally. One of these periodic events associated with climate variability is the El Niño phenomenon. Its role in the incidence of diarrhoeal diseases in children in Lima has been reported recently (5,6) and its long-term effect on cholera in Bangladesh (9-11).

Monitoring the environmental temperature is an interesting and promising method to predict outbreaks of diarrhoeal diseases. A time-dependant association between the warming of sea-water and cholera cases has been observed in Bangladesh for years (11), a net increase in diarrhoea and cholera cases was related to El Niño in Lima in children (5,6), and data from this report confirm that the association of diarrhoea and climate is also seen in adults. These data might be added to other methods to predict epidemics of diarrhoeal diseases in the future, such as monitoring environmental and sewage samples for *V. cholerae*, as its presence was detected months in advance of an epidemic in Lima (12,13), and potentially data from satellite imagery to sensor movement of plankton along the coastline, as plankton blooms may correlate with cases of cholera (11,14,15).

The proposed model could be used for predicting cases of acute diarrhoea in settings where methods are currently used for monitoring the environmental temperature and for evaluating the presence of cholera in the community. Predicting epidemics of diarrhoeal diseases may have a tremendous impact on healthcare strategies and in the management of health services in general. In this context, the timely allocation of appropriate material and human resources to reduce costs of care and to prevent further morbidity, such as acute renal failure secondary to severe and persistent dehydration, and mortality associated with these episodes is advised. Additionally, community education and promotion of healthcare should also be addressed. In conclusion, monitoring the environmental temperature and the presence of cholera in the community may be used for predicting the number of cases of diarrhoeal diseases in adults potentially seen in a public referral hospital.

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