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Temporal and spatial patterns of diarrhoea in the Mekong Delta area, Vietnam

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SUMMARY

This study examined the temporal and spatial patterns of diarrhoea in relation to hydro-meteorological factors in the Mekong Delta area in Vietnam. A time-series design was applied to examine the temporal pattern of the climate–diarrhoea relationship using Poisson regression models. Spatial analysis was applied to examine the spatial clusters of diarrhoea using Global Moran's *I* and local indicators of spatial autocorrelation (LISA). The temporal pattern showed that the highest peak of diarrhoea was from weeks 30–42 corresponding to August–October annually. A 1 cm increase in river water level at a lag of 1 week was associated with a small [0·07%, 95% confidence interval (CI) 0·01–0·1] increase in the diarrhoeal rate. A 1 °C increase in temperature at lag of 2 and 4 weeks was associated with a 1·5% (95% CI 0·3–2·7) and 1·1% (95% CI 0·1–2·3) increase in diarrhoeal risk, respectively. Relative humidity and diarrhoeal risk were in nonlinear relationship. The spatial analysis showed significant clustering of diarrhoea, and the LISA map shows three multi-centred diarrhoeal clusters and three single-centred clusters in the research location. The findings suggest that climatic conditions projected to be associated with climate change have important implication for human health impact in the Mekong Delta region.

Key words: Climate, diarrhoea, epidemiology.

INTRODUCTION

The Mekong Delta area (MDA) in Vietnam, where daily life is highly dependent on meteorological and hydrological factors, is the most vulnerable to climate change in South East Asia [1]. In the Mekong Delta, the air temperature is predicted to increase up to 4 °C in the period up to 2030 [2–6]. The sea level in the MDA could rise up to 1 m by 2100 – again by model scenario [4]. Annual rainfall is projected to increase on average from 0·3% to 8·8% during the 2020s–2100 s, and the annual rainfall will be more intensified and varied across the Mekong Delta basin [3, 4, 7, 8].

It has been suggested that elevated risk of water-borne diseases is associated with the alteration in hydro-meteorological factors such as river flooding, temperature, humidity, and rainfall [9–11]. For

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example, increases in water level, velocity and turbidity associated with annual flooding events can result in transporting pathogens from contaminated water sources to water supplies [12], therefore as a consequence, the risk of waterborne diseases, especially gastrointestinal illness and diarrhoea can increase [13–15]. Moreover, in developing countries, the lack of sanitation, inadequate hygiene behaviour, existing poor water quality and existing health conditions interact with extreme climate conditions to exacerbate water contamination and subsequent water-related diseases increasing the challenges associated with disease prevention and control [16, 17]. It is believed that understanding of current relationships between hydro-meteorological data and climate-sensitive diseases like diarrhoea plays an important role in evaluating and developing adaptation strategies for the future climate change impacts [18]. However, there is limited research to understand such existing relationships which limits the ability to estimate future health impacts.

While the patterns of the climate–diarrhoea relationship have been described elsewhere in the world [14, 15, 19], in which diarrhoea was found to be significantly associated with seasonality, there has been limited investigation of such a relationship in the Mekong Delta. In addition, due to the complexity in the association between meteorological factors and morbidity applied to different geographical areas, the study and adaption strategies may be better based in a specific region [20]. The objectives of this study are to (i) examine the temporal patterns of diarrhoea in relation to hydro-meteorological factors, and (ii) investigate the spatial patterns of infectious diarrhoea in a MDA in Vietnam.

METHODS

Research location

The study was conducted in Can Tho city, a central city in the Mekong Delta region in Vietnam. Can Tho is the fourth most populous city in Vietnam with a total area of 1411·49 km^2, a population of 1188390 people, and a population density of 842 people/km^2 [21]. Located in the heart of the Mekong Delta, where the river system intertwines with vast areas of orchards and rice fields, Can Tho residential life is highly affected by hydro-meteorological factors. The Preventive Medicine Centre of Can Tho City (CTPMC) has reported diarrhoea as the most frequent reason for hospital admission [22].

Data collection

Daily meteorological and river-water-level (RWL) data for the Mekong Delta section which runs through Can Tho city, were collected from the Southern Regional Hydro-Meteorological Centre from 1 January 2004 to 31 December 2011. The data were obtained from the hydro-meteorological station located at Can Tho city and included daily average temperature (°C), daily rainfall (mm) and average relative humidity (%).

Weekly counts of diarrhoeal illness from January 2004 to December 2011 were obtained from the disease surveillance reports of CTPMC. According to Vietnam's National Communicable Disease Control Law, diarrhoea is one of the communicable diseases that physicians in hospitals and clinics must report to the local health authority, and then the local health authority must report these cases to the next level of the health agency within 24 h. CTPMC is the leading health agency responsible for obtaining and analysing reported data for the purpose of disease prevention at the city level (Socialist Republic of Vietnam, 2007). Therefore, it is believed that the weekly counts of diarrhoea cases used here are representative of actual cases in the city over the study period.

Data analysis

Time-series regression analysis

A time-series design was applied to examine the temporal pattern of diarrhoea in relation to the hydro-meteorological factors of RWL, temperature, humidity, and rainfall, using generalized linear Poisson regression models allowing for over-dispersion. Time-series analysis is a useful technique to quantify the short-term association between environmental exposures and health outcomes [23]. To account for the seasonality and long-term trend of diarrhoea counts, a flexible spline function of time (3 D.F./year) was developed and input into the models. Several steps are involved in identifying the optimal model. First, the lag effect of each hydro-meteorological variable up to a lag of six previous weeks was examined using a univariately distributed lag model [equation (1)] adjusted for spline function of time and year.

$$\ln[E(Y)] = \beta_0 + \beta_1 M_{t-q} + i(\text{year}) + s(\text{time}), \qquad (1)$$

where $E(Y)$ is the expected weekly diarrhoeal rate; M is the hydro-meteorological variable (weekly average

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temperature, humidity, rain, RWL); i(year) is the year (2004–2011); and s(time) is the flexible spline function of time (3 D.F./year).

Second, the optimal lags of hydro-meteorological variables, which were statistically significantly associated ($P < 0{\cdot}05$), were identified and introduced into the Poisson multivariately distributed lag model. Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used to select the best predicted model. Third, we fitted natural cubic splines (3 D.F.) to the optimal lags of hydro-meteorological variables, adjusted for spline function of time, years and the offset of population simultaneously included in the model [equation (2)]. Finally, the predicted values of diarrhoeal rates were computed from the final model to examine the seasonal pattern of diarrhoea in the research location.

$$\ln[E(Y)] = \beta_0 + \mathrm{NS}(\mathrm{RWL_{op}}) + \mathrm{NS}(\mathrm{Temp_{op}}) + \mathrm{NS}(\mathrm{Humid_{op}}) + \mathrm{NS}(\mathrm{Rain_{op}}) + i(\mathrm{year}) + \ldots + s(\mathrm{time}) + \ln(\mathrm{Pop}), \quad (2)$$

where $E(Y)$ is the expected weekly diarrhoeal rate; $\mathrm{RWL_{op}}$, $\mathrm{Temp_{op}}$, $\mathrm{Humid_{op}}$, and $\mathrm{Rain_{op}}$ are average weekly RWL, temperature, humidity and cumulative rainfall during the optimal lag identified from equation (1); NS indicates a natural cubic spline function; i(year) is the year; and s(time) is the flexible spline function of time (3 D.F./year); Pop represents the population.

Spatial analysis

The spatial analytical method described by Dewan *et al.* [24] was applied to examine the spatial variation and clusters of diarrhoea cases in the research location. The average of diarrhoea cases from 2009 to 2012 was used for spatial analysis, since the last geographical relocation of communes was set up in 2009 in Can Tho city. The geographical unit used in the study was a commune, i.e. the smallest census unit in Vietnam, so there were 85 communes involved in the analysis. Due to high variability of shape, size and population distribution of the communes, use of raw incidence rate may not fully represent the relative magnitude of underlying risk. To address this problem, we applied the Empirical Bayesian (EB) smoothing technique [25] to our diarrhoea data. This method adjusts the raw rate by incorporating data from the neighbouring spatial communes [26], by which the raw rates are 'shrunk' towards an overall mean that is an inverse function of the variance. The advantage of an EB-smoothed incidence rate is that it not only produces better visualization compared to an unsmoothed rate but also serves to find true outliers [27]. The next step was to conceptualize the spatial relationship that defines neighbourhood structure around each census commune. Global Moran's I was first used to initially evaluate spatial clustering. If significant spatial autocorrelation was found, we then used local indicators of spatial autocorrelation (LISA) to evaluate the location of diarrhoea clusters [28]. An alpha level of 0·05 was set to test the statistical significance. We then plotted values onto a map to display the location of diarrhoea clusters in the research location.

RESULTS

Descriptive analysis

The descriptive statistics for diarrhoeal and hydro-meteorological factors for the study period January 2004–December 2011 are shown in Table 1. A total of 136 694 diarrhoeal cases were reported in the research location over the 416 weeks and the average number of diarrhoeal cases was 329/week [95% confidence interval (CI) 322–335] with an incidence rate of 2·8/10 000 person-weeks (95% CI 2·74–2·87). The wet season (May–November) had a higher incidence rate compared to the dry season (December–April), and the rate decreased from 2008 to 2011 (Fig. 1). The average temperatures were not different between dry and wet seasons (27 °C and 27·2 °C, respectively), but the average values of relative humidity were significantly different between the dry and wet seasons (77·6% and 83·2%, respectively). The number of weeks having at least one rainy day was 318 out of 416 weeks, of which 156 weeks had a cumulative rainfall above the average level (28·5 mm). The number of weeks with river water above the average level (120 cm) was 182 out of 416 weeks.

Temporal patterns of diarrhoea

The univariately distributed lag models indicated that RWL at lags 1 and 5, temperature at lags 2 and 4 and humidity at lag 2 were statistically significantly associated with the change in diarrhoeal rates ($P \leq 0{\cdot}05$); whereas rainfall was not statistically associated with the change in diarrhoeal rates over the six lags

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Table 1. *Descriptive statistics*

Variable	Statistics						
	Min	P25	P50	P75	Max	Mean	S.D.
No. of visits for diarrhoea (counts/week)	136	282	328	375	517	329	66
Average temperature (°C)	23	26·5	27·1	27·8	31	27	1·1
Average humidity (%)	62·6	77·8	80·7	84	91·4	80·7	4·6
Cumulative rainfall (mm)	0	0·25	16·3	44·1	169·1	28·5	34·1
Average river water level (cm)	62·7	101	116	140	194	120	26·5

P25, First quartile; P50, median; P75, third quartile; S.D., standard deviation.

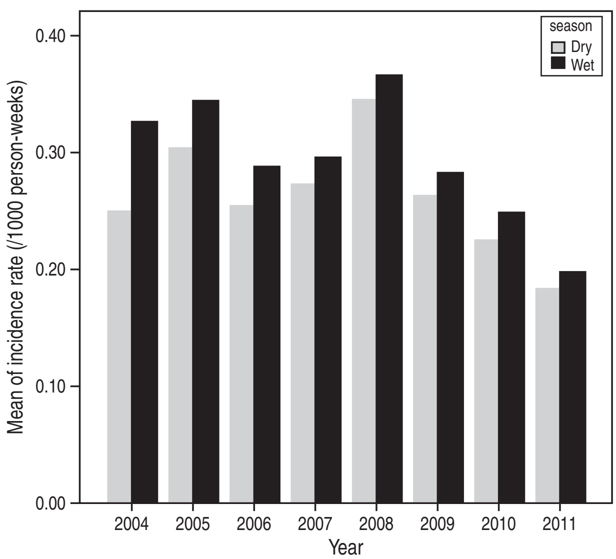

Fig. 1. Mean incidence rate of diarrhoea in dry (December–April) and wet (May–November) Seasons.

examined (Table 2). An increase in one unit of RWL (cm) was associated with a 0·07% (95% CI 0·01–0·1) increase in the diarrhoeal rate. A 1 °C increase in temperature for the previous 2- and 4-week average periods was associated with a 1·5% (95% CI 0·3–2·7) and 1·1% (95% CI 0·1–2·3) increase in diarrhoeal rates, respectively. By contrast, a 1% increase in relative humidity was associated with a 0·4% (95% CI -0·7 to -0·02) decrease in the diarrhoeal rate. The optimal multivariate predicted model using the significant lags of hydro-meteorological variables was identified with the inputs of RWL at lag 1, temperature at lag 4, and humidity at lag 2, adjusted for seasonal and long-term trend using the smallest AIC and BIC values (Table 3).

The temporal patterns of diarrhoea in relation to temperature and humidity are shown in Figure 2. Due to a very small change in diarrhoea associated with RWL, the RWL–diarrhoea relationship was not plotted here. The temperature–diarrhoea pattern was a positive linear relationship with the threshold of temperature ranging from 22 °C to 24 °C; whereas, the humidity–diarrhoea pattern appears to be a non-linear relationship, in which the risk of diarrhoea increased at both low and high humidity with the threshold of humidity at 80%. The temporal patterns of diarrhoeal rates over the years and within a year are presented in Figure 3. The predicted trend of the diarrhoeal rate decreased after 2008, which was the peak of diarrhoeal incidence in the research location during the study period (Fig. 3*a*). The seasonal pattern of diarrhoeal rates within a year show the highest peak of diarrhoea for weeks 30–42 corresponding to August–October annually, with rates decreasing towards the end of the year (Fig. 3*b*).

Spatial pattern of diarrhoea

The spatial variation and clustering of diarrhoea cases are presented in Figure 4. Geographically, the high incidence rates were observed in the communes grouped in the urban and peri-urban areas, in close proximity to the main river channel (Fig. 4*a*). The global spatial autocorrelation analysis using Moran's *I* is reported in Table 4. The findings revealed that there was significant clustering of diarrhoea cases in most of the years studied (2010–2012). A local spatial autocorrelation (LISA) map provides the most useful information in significant locations of spatial autocorrelation. High-high and low-low locations are typically known as hot and cold spots of an event; whereas, high-low and low-high are considered as spatial outliers [26]. The LISA map of 2009–2012 (Fig. 4*b*) indicated there were three multi-centred diarrhoeal clusters and three single-centred clusters in the research location. The first multi-centred cluster was

Table 2. *Univariate distributed lag models*

Lag (weeks)	River water level (mm)		Temperature (°C)		Humidity (%)		Rainfall (mm)	
	Change, %	95% CI	Change, %	95% CI	Change, %	95% CI	Change, %	95% CI
0	−0·01	−0·07 to 0·05	0·2	−1 to 1·3	0·1	−0·2 to 0·4	0·03	−0·007 to 0·006
1	**0·07***	0·01 to 0·1	0·3	−0·9 to 1·4	−0·1	−0·4 to 0·2	0·003	−0·03 to 0·04
2	0·02	−0·05 to 0·08	**1·5***	0·3 to 2·7	**−0·4***	−0·7 to 0·02	−0·03	−0·06 to 0·005
3	0·04	0·02 to 0·1	0·9	−0·3 to 2·1	−0·06	−0·4 to 2·9	−0·002	−0·03 to 0·03
4	0·01	−0·05 to 0·07	**1·1***	0·1 to 2·3	−0·2	−0·5 to 0·2	−0·01	−0·04 to 0·02
5	**0·07***	0·04 to 0·1	−0·3	−1·5 to 0·9	−0·04	−0·3 to 0·3	−0·003	−0·04 to 0·04
6	−0·01	−0·06 to 0·06	−0·4	−1·6 to 0·7	0·08	−0·2 to 0·4	0·01	−0·02 to 0·04

CI, Confidence interval.
* Statistically significant. The models adjusted seasonal and long-term trends using a flexible spline function of time (3 D.F. per year) and the year.

Table 3. *Identification of the optimal multiply distributed lag model*

Model	% change in diarrhoea rate	95% CI	AIC	BIC
Model 1				
Lag 1: RWL (cm)	**0·07***	0·04 to 0·13	1288	1437
Lag 2: Temperature (°C)	1·1	−0·2 to 2·5		
Lag 2: Humidity (%)	−0·2	−0·6 to 0·2		
Model 2				
Lag 1: RWL	**0·08***	0·01 to 0·14	1280	1431
Lag 4: Temperature	**1·3***	0·1 to 2·4		
Lag 2: Humidity	**−0·4***	−0·7 to (−0·01)		
Model 3				
Lag 5: RWL	0·06	−0·07 to 0·12	1283	1439
Lag 4: Temperature	1·2	−0·2 to 2·6		
Lag 2: Humidity	−0·2	−0·6 to 0·2		
Model 4				
Lag 5: RWL	0·06	−0·04 to 0·12	1281	1429
Lag 4: Temperature	**1·2***	−0·04 to 2·4		
Lag 2: Humidity	**−0·4***	−0·7 to (−0·005)		

CI, Confidence interval; AIC, Akaike's Information Criterion; BIC, Bayesian Information Criterion; RWL, river water level.
* Statistically significant. The models adjusted seasonal and long-term trends using a flexible spline function of time (3 D.F. per year), the year, and the offset of population.

located in the central neighbouring districts of Ninh Kieu and Cai Rang, and centred on three communes, namely Truong Thanh, Ba Lang, and An Khanh which had diarrhoeal rates that ranged from 170 to 291 cases/10 000 person-years. The second and third multi-centred clusters were located in rural districts of Vinh Thanh, Co Do, and Thoi Lai and comprised of five communes, namely Thanh Loc, Thanh Phu, Trung Hung, Thoi Lai, and Dinh Mon which had lower diarrhoeal rates ranging from 28 to 82 cases/10 000 person-years. Two single-centred clusters were located in peri-urban districts of O Mon and Thot Not including the Thoi Hoa and Tan Hung communes, and one cluster was located in the rural district of Co Do comprising a remote rural commune named Dong Thang. These were high-low clusters with diarrhoeal rates ranging from 121 to 170 cases/10 000 person-years.

DISCUSSION

This study assessed relationships between hydro-meteorological factors and diarrhoeal cases using time-series and spatial analyses to examine the seasonal and geographical patterns of diarrhoea in Can Tho city, in the Mekong Delta.

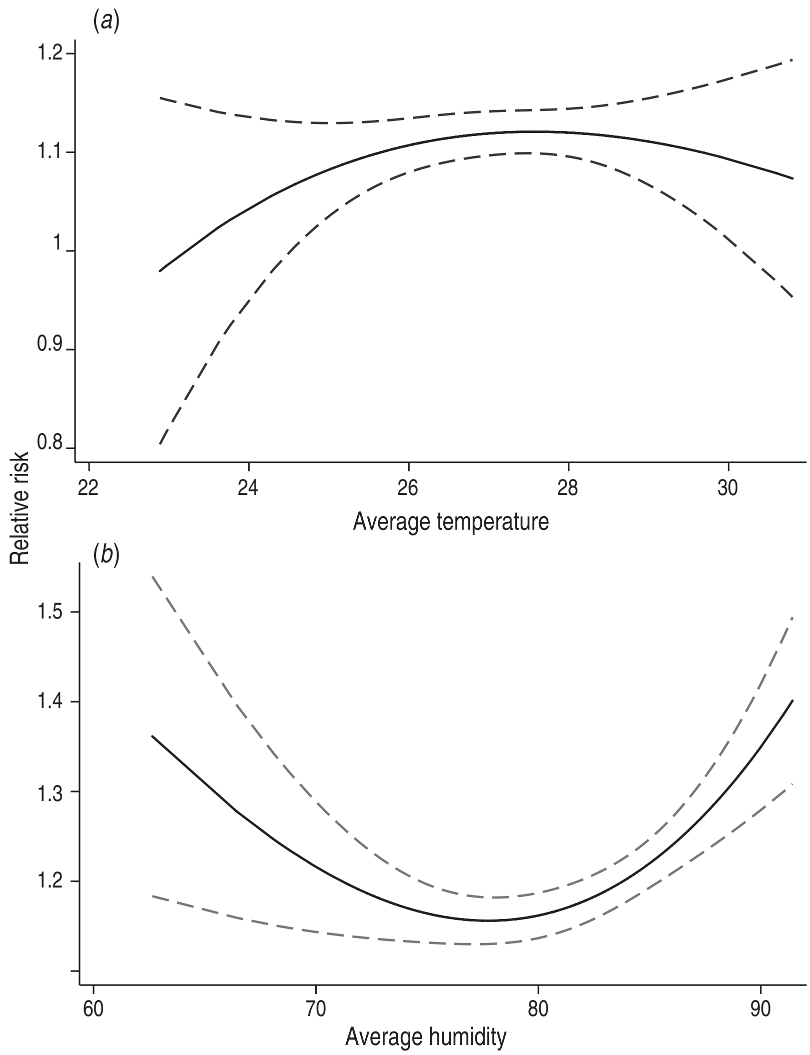

Fig. 2. Temporal relationship between the number of diarrhoeal cases and meteorological variables, including: (*a*) average temperature at lag 4; (*b*) average humidity at lag 2. RR represents the relative risk of diarrhoea. The centre line (——) in each graph shows the estimated spline curve of RR, and the dashed lines (- - -) represent the 95% confidence intervals.

The positive association between temperature and diarrhoea found in this study was consistent with those of previous studies worldwide. For example, a 1 °C increase in temperature was associated with a range of approximately 3–16% increase in outpatient diarrhoeal visits in China [11, 29]. Likewise, an 8% increase in the risk of severe diarrhoea in Peruvian children was found to be significantly associated with a 1 °C increase in temperature [30]. In sub-Saharan Africa, the prevalence of diarrhoea increased in young children as the average monthly maximum temperature increased [31]. The study in a sub-tropical area in Taiwan illustrated that maximum temperature was positively associated with increase in risk of diarrhoea-associated morbidity in children and older people, and had less effect on adults [32]. The mechanism underlying the present association between temperature and diarrhoea is still unclear; however, some plausible mechanisms exist [11]. First, replication and survival of pathogens that cause diarrhoea may be directly or indirectly influenced by temperature. For example, rotavirus and some bacteria that cause diarrhoea proliferate in warm marine waters [33] – cholera and warm water, and vectors such as plankton which carry microbes proliferate faster in warm waters. Second, diarrhoea caused by food poisoning happens more frequently in warm weather because the higher temperatures lead to increased and more rapid pathogen growth in foods [34]. Third, the change in temperature can result in variation of dietary patterns and hygiene behaviour. For instance, higher consumption of water

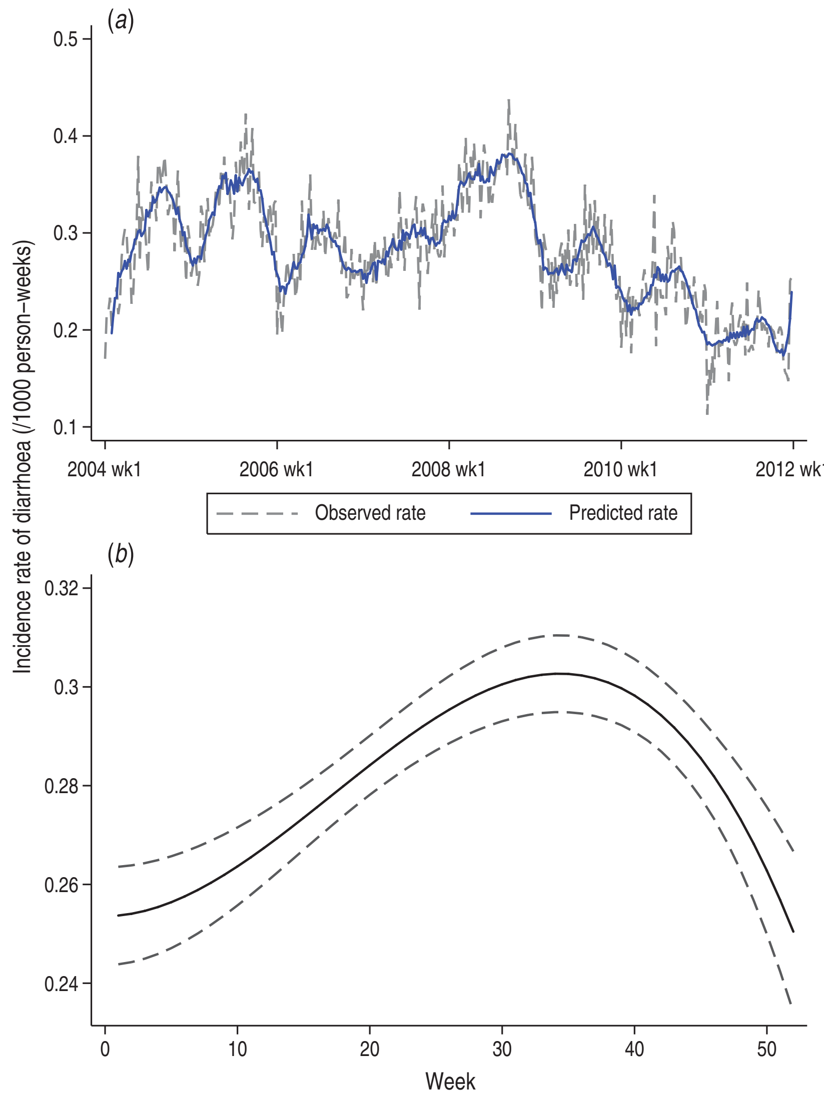

Fig. 3. (*a*) The observed and predicted incidence rate of diarrhoea in Can Tho city from 2004 to 2011. (*b*) The seasonal pattern of predicted incidence rates over 52 weeks of a year. The predicted rates were generated using equation (2) with the inputs of optimal lags, including: river water level at lag 1, temperature at lag 4, and humidity at lag 2 (Table 2). The centre line (——) indicates the incidence rate, and the dashed lines (- - -) represent the 95% confidence intervals.

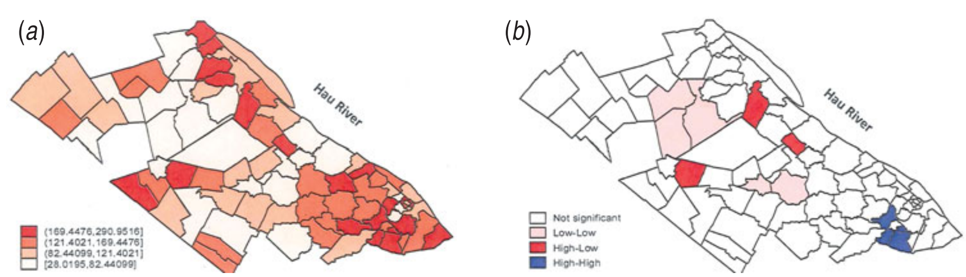

Fig. 4. (*a*) The Empirical Bayesian-smoothed incidence rates of diarrhoea (per 10000 person-years), and (*b*) the spatial clusters of diarrhoea in Can Tho City from 2009–2012.

on hot days and reduced consumption of hot, cooked foods could facilitate transmission of bacteria and other pathogens [35].

The nonlinear relationship between relative humidity and the risk of diarrhoea found in this study is consistent with findings of previous studies where

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Table 4. *Global spatial autocorrelation analysis of EB-smoothed diarrhoea cases in the research location*

	EB-smoothed diarrhoeal incidence rate			
Year	Moran's *I*	*Z* score	*P* value	Pattern
2009	0·064	1·117	0·132	Weakly dispersed
2010	0·111	1·782	0·037	Clustered
2011	0·167	2·588	0·005	Clustered
2012	0·116	1·864	0·031	Clustered

EB, Empirical Bayesian.

both positive and negative relationships were found dependent on the humidity level. A study in Taiwan found that relative humidity interacting with heavy rainfall contributed to increased risk of diarrhoea-associated morbidity in adults [32], although, many previous studies have reported a negative relationship between relative humidity and rotavirus diarrhoea in young children [36–38]. One study revealed that humidity alone did not significantly influence diarrhoea incidence but interacted with temperature to reduce the incidence of rotavirus diarrhoea [38]. A plausible explanation for this negative relationship was given by the laboratory evidence which showed that at low relative humidity, rotavirus can remain viable on plastic, glass and stainless steel for more than 10 days at room temperature [39, 40].

This study found an increased RWL was associated with a small increase in risk of diarrhoea in the research location. This is consistent with some previously reported findings, for example, an observed positive association between lagged weekly total water volume inputs and diarrhoea-related morbidity was reported in studies in North America [12–15] and in a tropical area, Bangladesh [36]. Another study conducted in the same location in the Mekong Delta found that the annual river flood pulse resulted in an increase in paediatric hospital admissions, mostly due to gastrointestinal illness [41]. The explanation for a higher RWL– diarrhoea relationship is the presence of contaminated water due to flooding. The RWL can serve as a marker for a flooding event, where heavy rainfall can cause expansion of the river channel, increase in water velocity, overland flow, and occurrence of shallow subsurface flow, resulting in high water turbidity and potentially transporting pathogens, so that drinking-water sources are contaminated [12]. Moreover, high turbidity levels can protect pathogens from natural disinfection, as well as hinder other disinfection techniques [19]. Therefore, the risk of exposure to waterborne pathogens is increased as a result of run-off and increased turbidity [13–15].

The findings of spatial analysis indicated that more multi-centre and single-centre clusters of diarrhoea cases were found in peri-urban areas compared with rural areas. This is possibly explained by the mixed pollutants from both agricultural activities and industrial wastes during flooding. Furthermore in peri-urban areas higher population density and limited standard sanitation facilities also have the potential to directly impact on diarrhoea rates as revealed by some studies of diarrhoeal risk in some peri-urban areas [42–44]. In addition, the interaction between climate factors and hygiene and sanitation status in peri-urban areas may also make a contribution to the clustering of diarrhoea cases. For example, the study by Hashizume *et al*. [36] conducted in Bangladesh indicated that the temperature had different effects on diarrhoeal risk between the subgroups studied, in which the risk of non-cholera diarrhoea was higher in those individuals with a lower educational attainment, those living in a household with a non-concrete roof and unsanitary toilet facilities.

Our study has numerous limitations. First, the dataset provided weekly counts of diarrhoea, which combined all causes, so the study was not able to analyse cause-specific diarrhoea. This may reduce the magnitude of the climate–diarrhoea relationship because microbiological agents interact with the weather factors. Second, most of the diarrhoeal cases that were reported to CTPMC were moderate or severe hospital-admitted cases, so we have not quantified the minor diarrhoeal cases. In Vietnam people can easily buy medicine in any private pharmacy to treat themselves or their children without hospital admission; however, the focus on data from hospital admissions provides a more accurate measure of more serious illness. Finally, this study was limited in analysing sensitivity to some potential confounding factors such as age, gender, hygiene behaviour, household economic and hygiene status due to a lack of data for these factors. The reason for this is that the diarrhoeal counts reported to CTPMC from the surveillance systems (e.g. hospitals, clinics, etc.) were cumulative counts of diarrhoea cases without individual or household factors. There is a need for better systematic data collection and surveillance systems to more accurately specify cases and to clarify the role of potential confounding and modifying factors in the relationships observed. In addition, an early warning system using forecast models which can be used to predict diarrhoea using weather factors should be developed for the purpose of prevention.

Despite some limitations, the current study revealed some important potential health impacts of climate change in Mekong Delta, in which the climate change-induced factors such as temperature, humidity, and river flooding were significantly associated with diarrhoea, the most frequent disease in this region. As mentioned earlier, these factors have been worsening over the past years and are attributed to climate change effects (e.g. increased temperature, rainfall, flooding intensity), so the evidence on current relationships will play an important role in evaluating changes in the context of projected climate changes for these particular factors and hence in predicting increased burden of disease in the community. For instance, an early warning system using associated climate factors to predict diarrhoea, which is the most epidemic disease in the MDA, can be developed and integrated into the surveillance system of local health authorities. In addition, the findings of this study can assist local health authorities to better allocate and prepare the healthcare stocks (e.g. hospital beds, equipment, medication, etc.) for diarrhoeal control under the context of changes in hydro-meteorological factors. This can play an important role in developing an appropriate climate change adaptation in the Mekong Delta region in Vietnam. In Vietnam, the communicable disease prevention and control programmes are community-based interventions, so the spatial clusters could be important findings for the local health department to consider with regard to better allocation of the programme's activities such as education, monitoring community sanitation and hygiene, improvements in commune clinics, etc., especially in high-high diarrhoeal clusters.

CONCLUSION

Using time-series and spatial analytical methods, we explored the temporal and spatial patterns of infectious diarrhoea in a typical MDA in Vietnam. The statistical analysis revealed significant relationships between the hydro-meteorological factors such as RWL, temperature, and humidity and risk of diarrhoea, indicating that any changes to these factors associated with climate change will have important implications for human health impacts in the Mekong Delta region in the future. Seasonal analysis showed that the risk of infectious diarrhoea is higher during the wet season, and cluster maps indicated higher incidence of diarrhoea in peri-urban areas. This analysis provides a useful insight into existing associations between hydro-meteorological factors and diarrhoea and hence assists local health departments to develop appropriate climate-change adaptation, health policy and preparedness for diarrhoeal prevention.

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DECLARATION OF INTEREST

None.

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