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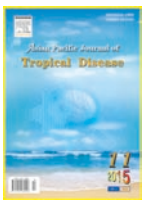

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Correlation between climate variations and rotavirus diarrhea in under-five children in Bandung

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ABSTRACT

Objective: To find correlations between climate variations (temperature, rainfall, humidity, and wind speed) and the prevalence of rotavirus diarrhea, particularly evinced by hospital admission.

Methods: Stool specimens were obtained from under five-year-old children suffering from acute diarrhea at the Dr. Hasan Sadikin General Hospital over the period from April 2009 to December 2012. Stool specimens were obtained from the sick children within 24 h of their hospital admission. Weather information was obtained monthly.

Results: From 945 stool specimens, rotavirus was positively identified in 427 (45.2%) of them. Correlation of rotavirus diarrhea prevalence to temperature, rainfall, humidity, and wind speed were amounted to r = -0.427, r = 0.101, r = 0.536 and r = -0.069, respectively. No significant correlation could be determined to link the prevalence of rotavirus to either the dry and the wet season (P = 0.939). A slight seasonal climate variation was shown in the dry season, where the rotavirus was found to be positive in 250 out of 552 specimens (45.3%). However, in the wet season, only 177 out of the 393 specimens (45.0%) were proved to be positive.

Conclusions: Our study showed that rotavirus is found year-round, and has a negative correlation to temperature, a moderate correlation only to humidity, but no significant correlation at all to either rainfall or wind speed.

1. Introduction

Diarrhea remains the second most potent cause of death in under five-year-old children globally[1]. Nearly one in five child deaths, about 1.5 million each year, are due to diarrhea. The rotavirus is the main cause of acute diarrhea and is responsible for about 40% of all hospital admissions. More than half of these cases are in Africa and South Asia, where diarrhea is more likely than elsewhere to result in severe outcomes including death. Differences in seasonal prevalence of rotavirus disease occur globally. Observations from several countries have challenged the traditional dogma that rotavirus disease is seasonal in temperate settings but not in tropical countries[2]. In Indonesia, the prevalence of under five-year-old children admitted to hospital due to the rotavirus is between 39% and 67%, between 10% and 49% of these young patients being treated as outpatients[3]. In a 2009 study conducted in Bandung, the prevalence of rotavirus is 47%[4]. Unlike many bacteriological agents causing diarrhea, rotavirus occurs in both temperate and tropical areas. Rotavirus infection is a universal disease in children, regardless of the level of prevailing hygiene or the quality of food and water. Children in developed countries are infected at the same ages and just as frequently as those in less developed countries[5].

Climate-related hazards in Indonesia are also caused by the location and movement of the tropical cyclones in the South Eastern Indian Ocean (January to April) and Eastern Pacific Ocean (May to December). Indonesia is a tropical country with dry season (April–September or May–October) when the average rainfall decreases, and wet season (October–March or November–April)[6].

Potential climate change in the tropics has been assessed in several studies, for example the study of Kolstad and Johansson, which predicted a temperature increase of 4% over land in the tropics by the end of this century[7]. However, considerable uncertainty remains concerning projections that might be made to relate incidence of diarrhea to such projected climate change[7].

Both cold and dry spells of weather have been postulated as causes

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of increase in hospital admissions for rotavirus related gastroenteritis. Many attempts have been made to suggest that exposure to inclement weather may increase the rate of rotavirus infection. It has even been speculated that changes in the relative indoor humidity may also be an important factor in the rate of rotavirus infection among young infants. Other studies suggested that monthly rainfall might be one of the most important environmental determinants of rotavirus infectivity[8].

The aim of this study was to identify real correlations between climate variations (temperature, rainfall, humidity, and wind speed), and the incidence of rotavirus diarrhea in Bandung, Indonesia.

2. Materials and methods

The subjects of the study were children aged less than five years old with acute diarrhea in the Dr. Hasan Sadikin General Hospital over a period from April 2009 to December 2012. Fresh stool specimens were obtained from enrolled children within 24 h of their admission, and stored between 4–8 ℃ before being tested at the Laboratory of Microbiology by using ProSpecT™ Rotavirus Microplate Assay for the detection of rotavirus antigen. Weather information such as the highest and lowest temperatures, humidity, rainfall, and wind speed were monthly obtained from Bandung Meteorology, Climatology, and Geophysics Agency.

The data were analyzed using Epi Info™ 7, *Chi*-square test and the Pearson correlation test. Dara was considered to be significant at $P < 0.05$.

3. Results

Tests were carried out on 945 stool specimens. Rotavirus antigen was detected in 427 of them (45.2%). Rotavirus infection rate was proportionally higher in boys than that in girls: 258 of the total 427 infected children were boys, while 169 of them were girls. The proportions were 60% and 40% for boys and girls, respectively. The peak period for rotavirus positive identification turned out to be the calendar month of January (71.0%) (Table 1). During the dry season (April–September), rotavirus were found positive in 250 out of 552 samples (45.3%) and 177 out of 393 (45.0%) during the wet season (October–March), which showed no significant correlation to the seasonal distribution of rotavirus ($P = 0.939$).

Table 1
Seasonal distribution of rotavirus in 2009–2012.

Month	No. of stool specimen	Rotavirus positive					
		2009	2010	2011	2012	∑	% Positive
January	62	-	33	4	7	44	71.0
February	61	-	11	12	5	28	45.9
March	58	-	9	15	5	29	50.0
April	74	16	14	11	1	42	56.8
May	90	17	9	16	6	48	53.3
June	81	15	7	13	8	43	53.1
July	110	20	18	7	7	52	47.3
August	92	14	14	3	5	36	39.1
September	105	15	7	2	5	29	27.6
October	60	4	7	3	0	14	23.3
November	84	18	3	9	5	35	41.7
December	68	14	3	6	4	27	39.7
Total	945	133	135	101	58	427	45.2

The monthly average distribution of climate variation showed that the highest temperature, rainfall, humidity and wind speed were 25.525 ℃, 376.8 mm, 82.9% and 3.56 kn, respectively, while the lowest were 23.675 ℃, 31.8 mm, 72.1%, and 2.94 kn, respectively (Table 2).

Table 2
Monthly average distribution of climate variation and rotavirus positive rate in 2009–2012.

Month	Climate variation				RP (%)
	T (℃)	Rainfall (mm)	Humidity (%)	WS (kn)	
January	24.090	220.7	81.5	2.94	71.0
February	24.315	353.3	82.4	3.56	45.9
March	24.395	295.8	80.4	3.24	50.0
April	24.705	212.0	80.4	3.00	56.8
May	25.525	225.4	80.1	3.00	53.3
June	24.060	101.3	78.0	3.00	53.1
July	23.675	99.0	76.8	3.00	47.3
August	24.195	31.8	73.2	3.00	39.1
September	24.870	99.5	72.1	3.00	27.6
October	24.590	213.9	76.8	3.00	23.3
November	24.430	376.8	82.9	3.00	41.7
December	24.550	319.5	81.3	3.22	39.7

T: Temperature; WS: Wind speed; RP: Rotavirus positive.

Figure 1 shows that rotavirus infection occured year-round with peaks and troughs. The highest peak was in January with 71% rotavirus positive in an average temperature of 24.09 ℃. The lowest (23.3%) was in October with an average temperature of 24.59 ℃. A negative correlation between temperature and rotavirus was found ($r = -0.427$), suggesting that when the temperature increased, the prevalence of rotavirus was low.

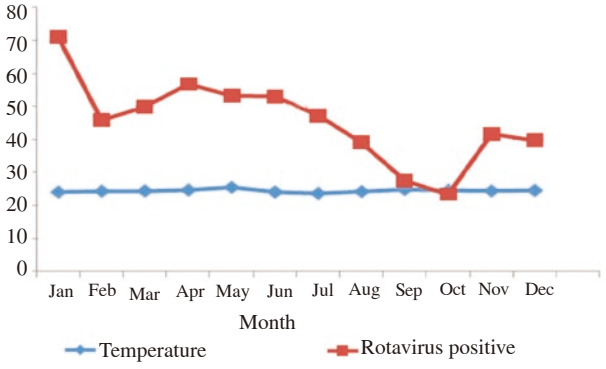

Figure 1. Monthly distribution of rotavirus in relation to temperature in 2009–2012.

Analysis of seasonal periods showed that in the dry season there was a low correlation between temperature and rotavirus positive identification ($r = -0.257$) while in the wet season there was a slightly stronger correlation ($r = -0.938$).

In monthly distribution, we found that November had the highest rainfall with a rotavirus positive identification rate of 41.7%. August had the lowest rainfall with a rotavirus positive identification rate of 39.1% (Figure 2). There was no significant correlation between rainfall and rotavirus positive identification ($r = 0.101$). The increased humidity was shown to increase the number of rotavirus positive identifications (Figure 3). Thus, humidity has a moderate correlation with rotavirus positive identification ($r = 0.536$). Wind speed as one of the contributing climate variables (Figure 4) showed no significant correlation at all ($r = -0.069$).

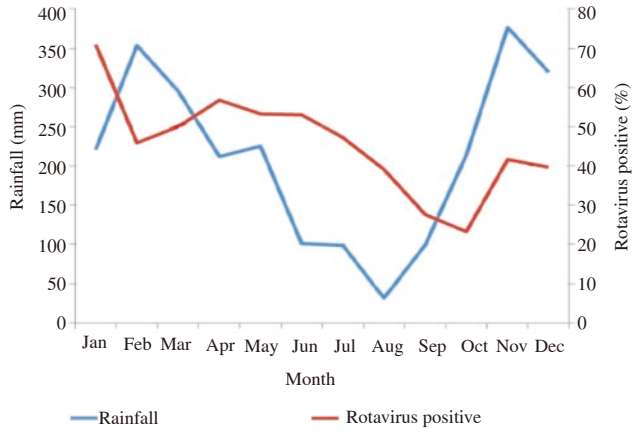

Figure 2. Monthly distribution of rotavirus positive identification in relation to rainfall during 2009–2012.

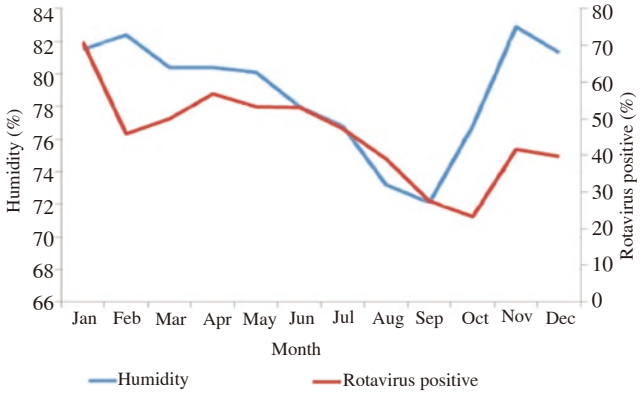

Figure 3. Monthly distribution of rotavirus positive identificantion in relation to humidity in 2009–2012.

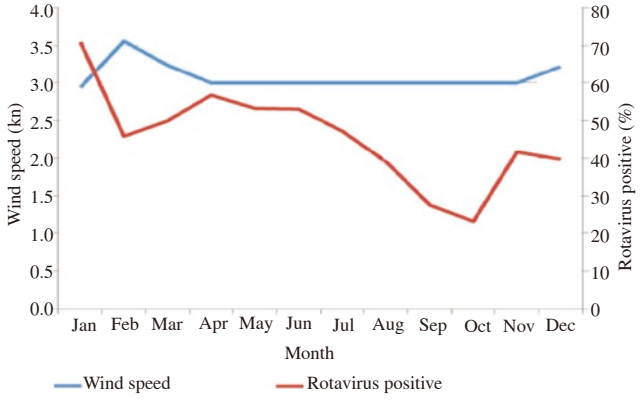

Figure 4. Monthly distribution of rotavirus positive identification in relation to wind speed during 2009–2012.

4. Discussion

It is to be observed that the hospitalization rate of rotavirus infected infant patients is much higher in the children younger than five years old than that in the children greater than five years old. Our study demonstrated that the rotavirus data of 4-year periodic mode were correlated with meteorological data available from the Dr. Hasan Sadikin General Hospital, Bandung, Indonesia (Table 1) over a 45-month period, April 2009 to December 2012.

The results of the study showed no statistically significant correlation between the seasonal distribution of rotavirus and the dry and the wet seasons (P = 0.939). Rotavirus infection was positively identified in 250 out of 552 specimens (45.3%) in the dry season (April–September), and in only 177 out of 393 specimens (45.0%) during the wet season (October–March). As a seasonal period, the dry season showed a low correlation whereas the wet season showed a slightly stronger correlation with the rate of rotavirus infection.

In a tropical country like Indonesia, the temperature is relatively similar between dry and wet seasons (average temperature 23.6–25.5 °C). This is similar to a previous study in terms that in the tropics the number of rotavirus detections was influenced by changes in climate, with the highest number of infections found in the colder and drier times of the year[9].

A study by Nguyen *et al*.[10] in 6 hospitals in North and South Vietnam found that, in the north, rotavirus infection was detected at rates above the annual median for 5 consecutive months in winter or spring and below the median in the summer and fall. This pattern was not presented in the south, where rotavirus infection occurred year round with hardly any seasonal variation. Rotavirus was detected in all sites every month of screening and never absented[10]. This is in contrast with another study in Southern Jordan, where the rotavirus infection rate is 39.9% in children. The lowest rate of infection occurred in winter[11]. However, this is similar to findings by Sumi *et al*. in Kolkata, India, where rotavirus infections were observed throughout the year, and the frequency of detection was higher during winter and pre-monsoon (December–May) with peaks in February 2008 and March 2009[12]. In South Asia, the highest rate of rotavirus infection was seen in the colder and drier months[13]. Another research found that, during the pre-rotavirus vaccine era, rotavirus caused marked winter seasonal peaks of gastroenteritis in the US[14]. Narci *et al.* also reported that the greater number of cases was to be found in winter[15]. The ongoing research into peak rotavirus activity in Japan has shifted gradually from winter to early spring for some unknown reasons[16].

In our study, temporal patterns of rotavirus infection and meteorological conditions were contributors. Our result identified the calendar month of January as the peak period for rotavirus infection (Table 1). The results of our study were similar to those obtained in other similar studies in other geographical areas. Our study showed that the rotavirus has a negative correlation with mean monthly temperature, similar to previous studies on the correlation between rotavirus infections and meteorological conditions[5,7,17].

A systematic review of 26 studies from 15 countries in tropical regions by Levy *et al.* consistently suggested an inverse relationship between monthly rotavirus incidence and climatological variation with a significant negative association with temperature[5]. Another study showed that higher temperatures were associated with a decrease in rotavirus diarrhea admissions in three Australian cities[7]. A significant positive association between the number of hospital visits for rotavirus diarrhea and temperature is also suggested by another study[17]. Temperature and precipitation in the previous month remain to be significant predictors and the association with temperature is stronger in tropical climates[12]. Hospitalization for rotavirus infection is strongly associated with mean temperatures in the Mediterranean island of Mallorca (Spain)[13].

High humidity seems to increase the identification of rotavirus within a moderately significant correlation (Figure 3). However, a Bangladesh study seems to suggest a negative association between high temperature, together with low humidity and the incidence of rotavirus diarrhea. Hashizume *et al*. showed that factors associated

with high temperature, low humidity and high river level increase the incidence of rotavirus diarrhea[18]. Furthermore, a study of three Australian cities showed that higher humidity may be associated with the decrease in rotavirus diarrhea admissions[7]. The increase in the prevalence of rotavirus during the drier and cooler months with lower relative humidity is consistent with some previous observations from other settings[19,20]. In a previous study, a significant relationship was noted between the mean relative humidity and the rate of virus detection. The rotavirus detection rate varies inversely with the humidity and reaches the highest when mean relative humidity is at its lowest. No virus is detected when mean relative humidity is at its highest and a higher relative air humidity would seem to lead to low viral detection rates[21,22].

No significant correlation seems to link rainfall (Figure 2) to rates of rotavirus infection at all. A study on relevant temperature and dependent transmissions of rotavirus infection in both Great Britain and Netherlands found no evidence of an association between the number of rotavirus infection cases and rainfall[19]. In a previous study, contrasting the correlation between rotavirus infection and meteorological conditions, a relationship between monthly rotavirus incidence and climatological variables was consistently found to have a significant negative association with rainfall[5,11]. The low viral detection rates could indeed be associated with a higher rainfall index[22].

The wind speed (Figure 4) showed no correlation at all with rotavirus infection, contradicting the findings of one study (which took place on the Mediterranean island of Mallorca, Spain) where the rate of rotavirus-induced hospitalization was positively associated with wind speed[19].

Our study showed that rotavirus infections will occur year-round with peaks and troughs, but without there being any significant correlation to either the dry or the wet season. Rotavirus infection is shown to have a negative correlation to temperature, a moderate correlation only to humidity, and no significant correlation at all can be identified that would associate rotavirus-induced infection with either rainfall or wind speed.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

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