

Climatic variables are associated with seasonal acute asthma admissions to accident and emergency room facilities in Trinidad, West Indies

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Summary

Objectives To determine if there is seasonal variation in acute asthmatic visits to accident and emergency (A&E) facilities in Trinidad and to identify the climatic variables associated with such visits.

Design and methods A retrospective census of patients with asthma, defined as those who required emergency bronchodilator nebulization, was taken at two A&E facilities in Trinidad from 1 January 1997 to 31 December 1999. The study included patients aged 64 years and under. Patient demographic data were obtained from the A&E records. Climate variables were taken from the island's sole Meteorological Office. Multiple regression was used to identify climate variables that were independent predictors of A&E asthma visits.

Results There were a total of 45 842 asthma admissions to the two facilities during the study period. Visits exhibited a cyclic pattern over the 3 years that varied according to the island's dry (January–May) and wet (June–December) seasons. There were more visits during the wet season than the dry (40 [SD = 2] vs. 32 [SD = 2] visits/day; $P < 0.001$). The results of multiple regression indicated that season ($P < 0.001$), barometric pressure ($P < 0.001$), temperature difference ($P < 0.001$), minimum temperature² ($P < 0.001$) and wind speed² ($P = 0.032$) were predictors of paediatric visits. Independent predictors of adult visits were season ($P < 0.001$), relative humidity ($P < 0.001$), minimum temperature ($P = 0.01$), temperature difference² ($P < 0.001$) and minimum temperature² ($P = 0.004$). Season and climatic variables explained 18% of the variance of the total A&E asthma admissions.

Conclusion There is seasonal variation in acute asthma visits to A&E facilities in Trinidad, which remains significant after controlling for climate variables. However, while climate has a role, there are other factors that may also be responsible for increased visits during the wet season. More research is needed to identify these factors.

Keywords accident and emergency facilities, asthma, Caribbean, climate, lesser developed country, Trinidad, tropics

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Introduction

Asthma is a growing public health problem worldwide. The prevalence of asthma has increased among children and young adults in many countries [1]. In the Caribbean, the prevalence of asthma also appears to have risen. In Barbados, for example, the prevalence of asthma among school-aged children has reportedly increased from 1% in 1970 to over 15% in 1996 [2, 3]. Furthermore, studies from the region that utilized the standardized International Study of Asthma and Allergy in Childhood (ISAAC) questionnaire and video instruments have suggested that the prevalence of the disease among school-aged Caribbean children is at the upper end of

the global scale. Thirteen percent of 13–14-year olds and 25% of 12–15-year olds from Barbados and Trinidad, respectively, reported wheezing in the year prior to the studies [3, 4].

There have also been reports of increasing numbers of patients seeking acute asthma admissions. For example, in Trinidad, with a total population of fewer than 1.3 million persons, there was an average 2200 monthly admissions for acute asthma management at four accident and emergency (A&E) facilities across the island during 1997 [5]. Despite high prevalence and acute asthma admission rates, there have been few studies on the aetiology of the disease in the region and possible triggers for acute asthma exacerbations.

Climatic conditions such as thunderstorms, extreme temperatures and high humidity have reportedly caused widespread exacerbation of asthma. A British study reported a major outbreak in asthma visits to A&E departments in the Greater London area after a thunderstorm, while another report from the United States found that a cold front,

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followed by a high-pressure system, preceded an asthma epidemic by 1–3 days [6, 7]. However, the specific nature of the association between these attacks and climatic conditions remains unclear [3]. Studies in temperate countries have reported on seasonal variation in asthma morbidity and asthma admissions to emergency rooms (ERs) [8, 9]. In England and Wales, asthma admissions were lowest in winter and peaked in autumn [9]. It is not very clear if seasonality in disease exists in the tropical islands of the Caribbean, which has only two seasons: a dry season that runs from January to May followed by a wet/rainy season that lasts the remainder of the year. However, the results of a study conducted in Mexico City, which has wet and dry seasons, indicated that asthma admissions were more frequent in the rainy season [10].

As far as we are aware, little research on asthma and its association with climatic conditions has been conducted in the anglophone Caribbean – a tropical zone. Reports from studies conducted in Barbados and Trinidad have shown increased attendance of patients to A&E departments in the latter half of the year, which coincides with the wet season [11, 12]. The report from Trinidad also indicated that asthmatic admissions to A&E departments were positively associated with temperature and wind speed in children and with temperature and relative humidity in adults [12]. While it was suggested in this report that there may be seasonality in asthma admissions, the study was only conducted over a 1-year period. To better understand seasonal variation in asthmatic hospital admissions and to further evaluate any associations with climatic variables, the present study was conducted in Trinidad over a 3-year period, 1997–1999.

Methods

Settings

The study was conducted in the tropical island of Trinidad, the larger of the two islands that comprise the Republic of Trinidad and Tobago. Trinidad is situated at the southern end of the Caribbean chain of islands approximately 11 km east of Venezuela. The island has a multi-ethnic population of approximately 1.3 million [13]. Public health care is provided free through a system of community-based health centres, district hospitals and general hospitals. The health facilities, San Fernando General Hospital (SFGH) and Arima Healthcare Facility (AHF), selected for this study were located at opposite ends of the island: one in the southwest (SFGH) and the other in the northeast (AHF).

SFGH, situated in the island's second largest city, provides secondary- and tertiary-level care to the population in the southern half of Trinidad. AHF, in the island's third largest town, provides primary- and secondary-level care to the densely populated town of Arima and its environs. SFGH and AHF are situated within 50 km of the island's sole Meteorological Office.

Study design and subjects

A retrospective census of persons seeking care for asthma at the A&E departments of the SFGH and AHF was conducted for the period 1 January 1997 to 31 December 1999. An asthma patient was defined as anyone who presented to the

A&E centres with symptoms consistent with a diagnosis of acute asthma and received bronchodilator nebulization.

Measurements

Each patient's age, gender and date of visit were obtained from the A&E records of the two study centres. Elderly patients, aged 65 years and greater, were excluded from the study due to problems with diagnosis and misclassification [12].

Data on these climatic variables were obtained from the Meteorological Office of Trinidad and Tobago and included daily readings of average relative humidity (%), total rainfall (mm), maximum and minimum temperature (°C), average wind speed (knots) and average barometric pressure (kPa).

Data analysis

For the analysis, total daily visits included a tally of daily visits to the two study sites. The sample was divided into two age groups: paediatric (<16 years) and adults (16–64 years). An upper limit of 15 years was used for the paediatric populations since this is the age limit for admission to paediatric wards in Trinidad.

There are two seasons in Trinidad: the dry season extends from January 1 to May 21 and the wet season from May 22 to December 31. Differences between the two seasons for asthma visits and climate variables were examined using the *t*-test. Total rainfall was log transformed because of its skewed distribution.

Spearman's rank correlation [14] was used to describe the bivariate associations between asthma visits and the climatic variables. Stepwise multiple regression [15] was used to identify those climatic variables that were independent predictors of asthma visits. For this analysis, the independent variables included season and the 3-day moving average of temperature difference (the difference between the minimum and maximum temperatures) and all the other climate variables excluding maximum temperature. The temperature difference was used as a measure of the level of temperature extremes over a 1-day period. Three-day moving averages were used to address autocorrelation. For the regression analysis, we also examined whether there were non-linear associations between the climatic variables and asthma visits. Consequently, quadratic terms of the independent variable were included in the regression models. The dependent variable was the 3-day moving average of asthma visits to the A&E centres. This was log transformed, as it was not normally distributed.

Analyses were conducted with the total data set as well as the data disaggregated by age group. The level of statistical significance was set at $P < 0.05$ and the data were analysed using SPSS for Windows version 9.0 [16]. To test for seasonality in visits over the 3-year period, the Kolmogorov-Smirnov test was used [17].

Results

A total of 45 842 asthmatic visits were made to the two A&E facilities between 1 January 1997 and 31 December 1999.

Table 1. Daily climate variables and asthma visits by season

	Dry season* mean (SD)	Wet season† mean (SD)	Mean difference	95% CI	P-value
<i>Climate variables</i>					
‡Total rainfall (mm)	117 (4.5)	3.8 (5.2)	2.3	(1.7, 3.0)	<0.001
Relative humidity (%)	80.1 (5.1)	84.9 (4.7)	-4.8	(-5.4, -4.3)	<0.000
Minimum temperature (°C)	22.9 (1.4)	23.9 (0.9)	-0.9	(-1.1, -0.8)	<0.001
Average pressure (hPa)	1013.5 (1.0)	1012.9 (1.6)	0.6	(0.4, 0.8)	<0.001
Temperature difference (°C)	8.8 (1.7)	8.4 (1.8)	0.4	(0.3, 0.6)	<0.001
Average wind speed (knots)	6.6 (1.9)	4.6 (1.9)	2.1	(1.8, 2.3)	<0.001
<i>‡Asthma visits</i>					
Paediatrics	15.7 (1.8)	19.0 (1.8)	3.3	(2.2, 4.4)	<0.001
Adults	18.0 (1.6)	21.4 (1.5)	3.3	(2.3, 4.5)	<0.001
Total	35.2 (1.5)	41.8 (1.5)	6.6	(5.5, 7.7)	<0.001

*Dry season: 1 January to 21 May. †Wet season: 22 May to 31 December. ‡Total rainfall and asthma visits were log transformed before analysis and the geometric means presented.

Females accounted for 52.3% and adults for 51.2% of the visits. The age range of the sample was from 3 months to 64 years, with a mean age of 23.0 years (SD = 19.8 years).

A comparison of climate variables in the dry and wet seasons revealed that the rainy season was characterized by higher levels of rainfall, temperature, relative humidity and lower levels of barometric pressure, daily temperature difference and wind speeds (Table 1).

The results of the Kolmogorov-Smirnov test indicated that the asthma visits were not uniform over the 3-year period ($P < 0.001$). There was evidence of a seasonal pattern in daily asthma visits (Fig. 1); this coincided with the island's wet and dry seasons, with increased visits during the latter part of the wet season in each of the 3 years examined. Visits peaked around September, remained elevated and gradually decreased towards the end of the year. When further analysed by age group, it was found that this seasonal pattern was replicated in both the paediatric and adult populations.

The correlations between A&E admissions and climate variables were low but statistically significant with the exception of total rainfall (Table 2). For the total sample, there were positive associations with relative humidity and temperature difference. On the other hand, barometric pressure, minimum temperature and wind speeds were negatively associated with total asthma visits. The associations between paediatric and adult visits and climate variables were similar to those for the total sample, but there were no associations with barometric pressure in adults and temperature difference in children (Table 2).

The results of the multiple regression analyses for asthma visits are summarized in Table 3. Season was an independent predictor of asthma visits for total visits as well as paediatric and adult visits. Total visits were also predicted by the linear terms of humidity and pressure and the quadratic terms of humidity and minimum temperature. Paediatric visits were also predicted by barometric pressure (linear), the difference in temperature (linear), wind speed (quadratic) and minimum temperature (quadratic), while adult visits were predicted by relative humidity (linear), minimum temperature (linear and quadratic) and temperature difference (quadratic). Season and climate variables accounted for 18% of the variance for total and adult visits and 14% of the variance of paediatric

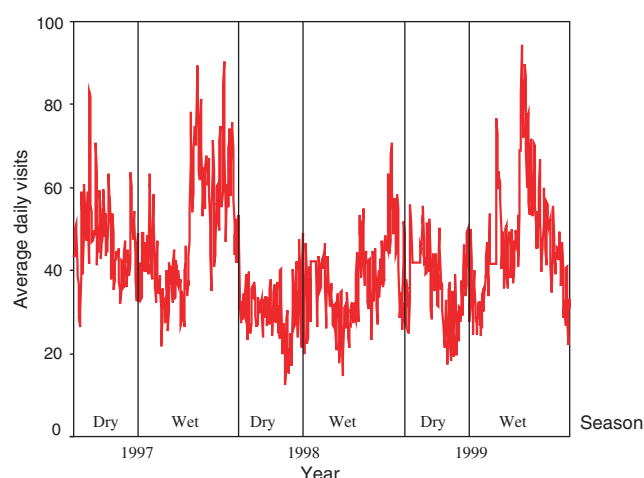


Fig. 1. Seasonal pattern of total asthma visits (3-day moving average) to emergency room facilities for the period 1997-1999.

visits (Table 3). The analysis was also conducted without season as a variable. Climate variables then accounted for 13% of the variance for total visits, 11% of the paediatric visits and 12% of the adult visits.

Discussion

Our results show that there is seasonality in acute asthma visits to ER facilities in Trinidad, with visits being more frequent during the wet season (June-December) than the dry season. Moreover, there is a clustering of visits in the latter half of the rainy season (September-December). These results are consistent with published observations from other tropical zone countries such as Mexico [10] and anecdotal reports from other Caribbean territories such as Barbados and Antigua [11, 18]. A particularly remarkable finding was that season was a predictor of asthma visits, independent of climate variables. This indicates that seasonal factors, in addition to the climate variables examined, are responsible for visits to A&E centres in Trinidad. As far as we are aware, there has been no widely accepted explanation given for the

Table 2. Correlation between the climate variables and asthma visits, by age group

Climate variables	Asthma visits		
	Paediatric	Adult	Total
Total rainfall (mm)	0.02	0.02	0.03
Relative humidity (%)	0.08*	0.10*	0.11*
Average barometric pressure	-0.14*	-0.04	-0.11*
Minimum temperature (°C)	-0.14*	-0.08*	-0.14*
Temperature difference (°C)	0.06	0.09*	0.09*
Average wind speed (knots)	-0.09*	-0.16*	-0.15*

* $P < 0.01$ **Table 3.** Results of the backward multiple regression analysis showing the independent* predictors of asthma visits

Asthma visits	Climate variables	Coefficients	P-value	Adjusted R^2
Total				0.18
	Season	-0.31	<0.001	
	Relative humidity	2.08	0.014	
	Pressure	-0.12	<0.001	
	Relative humidity ²	-1.98	0.019	
	Minimum temperature ²	-0.36	<0.001	
Paediatrics				0.14
	Season	-0.298	<0.001	
	Pressure	-0.179	<0.001	
	Temperature difference	-0.140	<0.001	
	Minimum temperature ²	-0.422	<0.001	
	Wind speed ²	0.082	0.032	
Adults				0.18
	Season	-0.298	<0.001	
	Relative humidity	0.175	<0.001	
	Minimum temperature	2.271	0.010	
	Minimum temperature ²	-2.484	0.004	
	Temperature difference ²	0.177	<0.001	

Season: dry = 1, wet = 0.

The 3-day moving average of the independent predictors and dependent variables (log transformed) were used.

*The following independent variables were entered into the regression model: season as well as linear and quadratic terms of log rainfall, relative humidity, barometric pressure; minimum temperature, temperature difference and wind speed.

seasonal variation in asthma admissions observed in the tropics, although there have been various hypotheses.

It is of interest that for the monthly asthma admission pattern seen in the tropical island of Trinidad, a dramatic rise in acute asthma admission from September until December is very similar to that previously described for paediatric asthmatics in England and Wales, located in a temperate zone [9]. This raises the possibility of common exacerbating factors such as viral infections that may cycle the globe during these months. Long-distant movement of viruses and other respiratory pathogens may be facilitated by the increased tourist travel during summer months. Additionally, in the Caribbean there is current interest in the possibility of spread of human pathogens via Sahara dust: dust clouds that move across the Atlantic from Africa. These clouds are reputedly brought to the Caribbean, Central America and southern North America in the summer [19]. It may be envisaged that

the introduction of new pathogens in the summer will require a lag period for circulation in the population, leading to infection-induced asthma exacerbation in the autumn. In Costa Rica, it has been reported that paediatric asthma admissions increase in March and August, immediately after children return to school after the end of holidays in February and July. The author suggested that the spread of viral infection was the likeliest cause for the dramatic increases observed [20].

The hotter, more humid and wetter conditions that prevail in the rainy season would facilitate increased moisture and dampness within homes; this in turn may favour increased growth of indoor allergens, notably house dust mite and fungi. In the Caribbean, dust mite sensitivity is high among asthmatics [1, 18] while sensitivity to indoor and outdoor moulds is less well defined but appears to be low. A study of house dust mite levels throughout the year on the island of St Lucia showed that dust mite levels remain high throughout the year and at levels commonly associated with symptoms [21]. It is unlikely that any increase in the rainy season will lead to further symptoms. It could be argued, however, that patients may remain indoors for longer periods during the rainy season and are thus more exposed to mites for longer periods. With regard to mould sensitivity, as far as we are aware there have been no systematic studies of mould exposure in the Caribbean.

There is little available information on pollen allergy in the Caribbean and its possible impact on the development, or exacerbation, of allergic asthma [18]. Blades and colleagues in Barbados assessed the possible impact of pollen and fungal spores on asthmatic attendance at the island's main A&E department by trapping pollen from the air at two sites on the island from May to October 2000. They reported that grass pollens accounted for 95% of all pollen trapped, of which the most common species was *Andropogon intermedius* (rare blue grass). They also reported a 'noticeable increase in grass pollen concentration during September and October coinciding with increased visits to the asthma bay' [22]. Pollen counts did not however correlate with acute asthmatic attendance in the dry season. A report on air sampling from Venezuela, which is situated only 15 miles from Trinidad, showed that while there was a great diversity of moulds in an annual spore count, the contribution of individual moulds was rather low, and it was unlikely that airborne moulds are important aeroallergens in Venezuela [23]. These authors also described a grass pollen peak in November, which they thought might be associated with seasonal symptoms.

The results of the multiple regression clearly indicate that climatic variables were predictors of asthma visits in Trinidad. The relationship between individual variables and asthma visits was both linear and quadratic. Additionally, paediatric and adult admissions were associated with different combinations of climatic variables. Overall however, visits increased when relative humidity was high and barometric pressure low, coupled with quadratic effects from decreased minimum temperature and relative humidity. High relative humidity and low barometric pressure are climatic features of the rainy season, yet in Trinidad asthma admissions cluster in the latter half of the rainy season. It is difficult to explain the additive quadratic effects of decreased minimum temperature since the rainy season has higher minimum and maximum

temperatures. It is likely that since climate variables account for only 14% and 18% of variance, there are complex interactions between these climate variables and other factors such as air pollution and airborne pollens in exacerbating asthma.

The main limitation of this study was in the definition of an asthmatic as any person who presented to the ER and required bronchodilator nebulization. The use of a bronchodilator is not sufficient to establish a diagnosis of asthma. The implications of persons presenting with symptoms that manifest as asthma, such as heart failure and chronic obstructive pulmonary disease, may have been minimized by the small proportion (15%) of persons over 50 years of age in the study. Additionally, the measurement of average daily climatic variables does not take into account local variation in climatic conditions such as variation in wind speed. As a result, we may well underestimate the impact of climatic variables in each patient's microenvironment.

In conclusion, the results of the present study indicated that asthma visits to ER facilities in Trinidad were seasonal, with more visits occurring in the wet than in the dry season. Climatic variables were involved with the association being both linear and non-linear; however, other factors may also be responsible. It is hoped that our findings will form the basis of further research on the mechanisms for the seasonality in asthma visits seen in the Caribbean. A knowledge of the aetiology of seasonal asthma visits will assist in the development of long-term asthma management plans at health-care facilities in Trinidad and Tobago and the region at large.

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