The Incidence of Asthmatic Attacks in Barbados

CA Depradine, EH Lovell

ABSTRACT

Asthma is a chronic disease in Barbados with a mean of 10 348 cases per year. This study was undertaken to determine the demographic distribution of the asthmatic attacks, their relationship with several meteorological variables and to provide a predictive equation. The study used data on asthmatic attacks provided by the Accident and Emergency Department of the Queen Elizabeth Hospital and meteorological data from the Barbados Meteorological Office and the Caribbean Institute for Meteorology and Hydrology. The study found that the greatest number of asthmatic attacks occurred in children aged five years or younger, that there was an exponential decrease in asthmatic attacks with age, that the incidence was higher on the eastern side of the island and that there was a higher incidence in males than in females. The statistical analysis found the highest correlations with vapour pressure and a three-week lag relationship between vapour pressure and asthmatic attacks. A stepwise regression analysis provided a predictive equation.

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RESUMEN

El asma es una enfermedad crónica en Barbados con un promedio de 10 348 casos por año. Este estudio fue emprendido para determinar la distribución demográfica de los ataques asmáticos, su relación con varias variables meteorológicas y para proporcionar una ecuación predictiva. El estudio usó datos sobre ataques asmáticos suministrados por el Departamento de Accidentes y Emergencia del Hospital Queen Elizabeth y datos meteorológicos de la Oficina Meteorológica de Barbados y el Instituto de Meteorología e Hidrología del Caribe. El estudio halló que la mayor parte de los ataques asmáticos ocurrió en niños de cinco años de edad o más joven, que había una disminución exponencial en los ataques asmáticos con la edad, que la incidencia era más alta en el lado oriental de la isla y que había una incidencia más alta en los varones que en las hembras. El análisis estadístico halló las correlaciones más altas con la presión de vapor y una relación de retraso de tres semana entre la presión de vapor y los ataques asmáticos. Un análisis gradual de regresión proporcionó una ecuación predictiva.

INTRODUCTION

Barbados (13° 10'N, 59° 32'W) is the most easterly of the Caribbean island chain. It is a small island of approximately 430 km² and is divided into eleven parishes. The most recent census found a population of 268 792 persons comprising 129 241 males and 139 551 females. The urban parish of St Michael has the largest population of 91 025 persons and the highest incidence of asthmatic attacks.

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The World Meteorological Organization (WMO–No 892) states that the incidence of asthma has been increasing in many countries in recent decades but the reasons for this are not very clear. Acute episodes of asthma, however, have been linked to the presence in the air of certain dusts, pollen, particles from animal furs, ozone, other air pollutants or a mixture of some of these.

Numerous studies have established stochastic relations between medical data and weather elements. Several of these appeared in the 1970s (1, 2) and the 1980s (3, 4) and established relationships between asthma and meteorological variables such as temperature, barometric pressure, humidity and wind. Many of the more recent studies (5–7) have focussed

on the effects of aeroallergens such as air pollution, nitric oxide and ozone.

Indoor air pollution, largely due to the use of biomass fuels in ill-ventilated houses, is a major cause of respiratory disorders, particularly in women and children. Increasing vehicular traffic causes air pollution and noise pollution in urban areas (8).

A previous study (9) found that the house dust mite and household pests play a significant role in the incidence of allergy among Barbadian asthmatics. A relationship between asthmatic attacks and meteorological data in Barbados (10), using monthly data for the period 1972–1982, found positive correlations with rainfall and relative humidity. Positive associations with relative humidity and vapour pressure and a negative correlation with wind speed were found using daily asthmatic and meteorological data for the periods 1983 and 1989–1991 (11).

The present study analyses the demographic distribution of asthmatic attacks in Barbados, carries out a statistical analysis of the data and seeks to establish a predictive equation for the number of asthma cases as given by the meteorological variables.

Of interest to this study is the work (12, 13) which was carried out on the boundary layer in Barbados and which found high ozone concentrations, low nitrate and lead compounds during the winter and spring months and much lower values of ozone and higher values of nitrates during the summer months. The analyses indicated that the higher values of ozone and low values of nitrates during the winter-spring months were associated with transport from higher latitudes and higher altitudes while the summer values were associated with transport from Africa. This suggests that many allergens are transported into Barbados from external sources.

SUBJECTS AND METHODS
The asthma data used in this study were obtained for the eight-year period, 1996–2003 and January to October, 2004, from the records of the Accident and Emergency Department of the Queen Elizabeth Hospital, the lone major hospital on the island. The vapour pressure, relative humidity and wind speed were obtained from the Meteorological Office at Grantley Adams International Airport for the period 1996–2000 and the temperature and rainfall from the records at the Caribbean Institute for Meteorology and Hydrology for the same period.

The demographic distribution of the asthmatic attacks used the available data for the entire period, but the statistical analysis for the associations used data for the five-year period, 1996–2000. Furthermore, this study limited the correlation analyses to the asthmatic attacks in the parish of St George. The authors considered that by choosing a single parish and the rainfall stations in that parish more reliable relationships could be found than in previous studies which used island-wide asthmatic data and a single rainfall station.

The parish of St George was chosen because it is a high rainfall area and also has the second highest incidence of asthmatic attacks. Three rainfall stations were selected and the data averaged on a daily and weekly basis.

To reduce some of the variability in the data, a five-term running average was applied to the weekly average of the meteorological variables with the precipitation restricted to St George. Simultaneous and multiple correlations were obtained between the asthmatic attacks and the meteorological variables. Spectral and cross-correlation analyses were also carried out.

The demographic distribution of the asthma data used the monthly and total cases for each year. The incidence, defined as the number of cases per thousand for the total population and for the population of each parish, was determined from the nine-year averages. The ages of the patients were ranked in ascending order and the five-year totals determined starting at 0–5 years. The gender distribution was also found for each parish and the incidence determined for both males and females.

Previous studies (10, 11) have described the annual variation of asthma data using the calendar year. This distribution suggested a high value in January falling to a minimum in April and subsequent increases to October. In this study, we looked at an "asthmatic year", defined as the period from April of a given year to March of the following year. The resulting plot avoids having to explain high values in January but shows this as merely a part of the decreasing values from the maximum in October to a minimum in April.

The classical procedure of simultaneous correlation was used to identify relationships between the asthma data and the meteorological variables. Generally weak but statistically significant correlations were found. This procedure, however, is inadequate because of the time lapse that exists for the strongest associations to occur between comparative events in the meteorological and asthma data.

The use of lagged cross-correlation provides an unbiased method for the evaluation of statistical associations in comparative events and allows the time lapse factor which occurs in bio-meteorological events to be taken into account. The cross correlation at *lag k* measures the strength of the linear relationship between the value of a variable at time *t* and the value of the comparative variable *k* periods earlier. Lagged cross-correlation was therefore used to determine the strongest associations between the meteorological variables and the asthma cases.

A spectral analysis was also carried out on the data to determine the proportion of the total variance in the series that may be attributed to fluctuations within the given time periods.

To determine the predictive model, all the meteorological variables were used in a multiple regression analysis and those significant at the 90% or lower level were sequentially removed leaving a model with variables significant at

the 95% or higher level (15). The statistical package, STAT-GRAPHICS plus, was used to carry out the computations (16).

RESULTS

The incidence, by parish, of the asthmatic attacks across the island is shown in Figure 1 using the GIS programme Arc
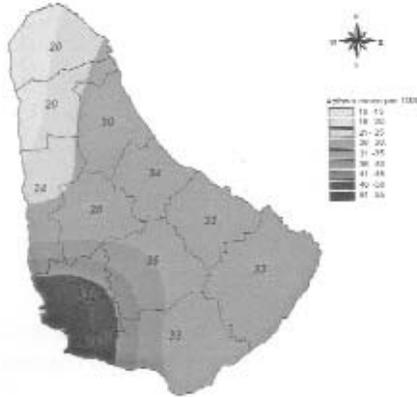
Fig. 1:   The incidence (cases/1000 population) of asthma cases for the annual average year (1996–2004).

View.   The programme uses mathematical procedures to draw isolines to illustrate the variation in various bands and shows the highest incidence in the Bridgetown area.

The urban parish of St Michael had the highest incidence of attacks (52.2 per thousand population per annum) and Table 1 shows the annual percentage variation for this

Table 1:   Annual asthmatic attack rate for St Michael for the period 1996–2003

Year	1996	1997	1998	1999	2000	2001	2002	2003
Rate %	6.02	6.89	4.78	5.30	4.72	4.50	4.62	5.45

parish for the period 1996–2003.

The attack rate per 100 population per annum for each parish is shown in Figure 2. It is evident that the lowest rate
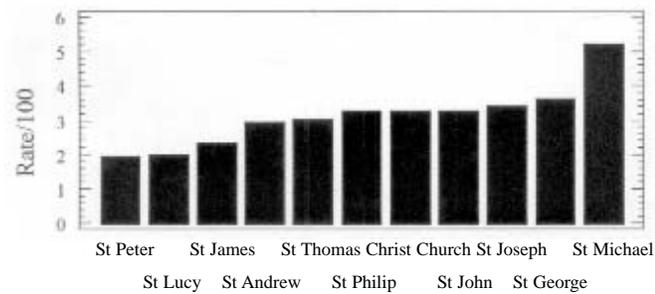
Fig. 2:   Asthma attack rate per 100 population per annum for each parish.

was in St Peter (1.9%) and the highest was in St Michael (5.2%). It should be noted that the population of St Peter (11405) on the west coast of the island is larger than that of

St Andrew (5613), St John (9448) and St Joseph (7244) on the east side.

The "asthmatic year" distribution is shown in Figure 3 for the years April 1997 to March 1998, April 2001 to March
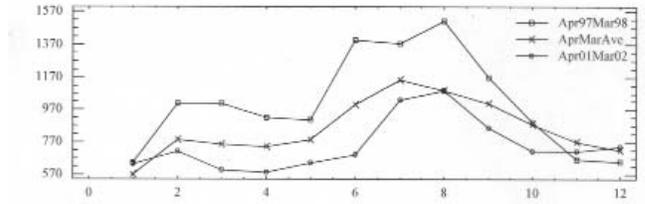
Fig. 3:   Monthly distribution of asthma cases April–March, 1997-1998, 2001–2002 and the eight-year average (1996–2003).

2002 and for the nine-year average 1996–2004. This represents the monthly distribution beginning from the minimum month, April, and ending 12 months later. The distribution of the annual number of asthmatic attacks is shown in Figure 4.
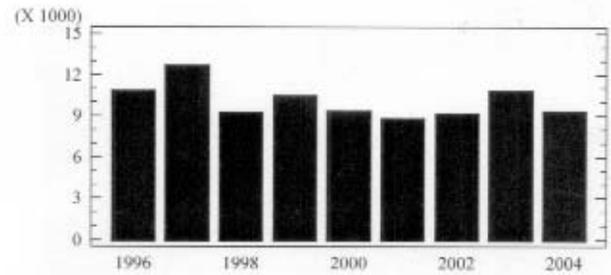
Fig. 4:   Annual distribution of asthma cases, 1996–2004. Note that data for 2004 are for months January to October.

With the exception of 1997, all other years were in the 10 000 to 11 000 range.

The distribution by gender for each year is plotted in Figure 5. It is evident that there are more male asthmatic
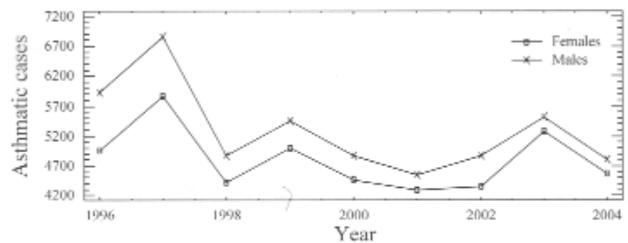
Fig. 5:   Annual number of male and female asthma cases, 1996–2004. Note that data for 2004 are for months January to October.

cases than female cases in each year. This results in a nine-year average of 4799 female cases and 5300 male cases. Using these averages, there is an overall attack rate of 3.4 per cent of the female population and 4.1 per cent of the male population. If we use a nine-year average of 10 348 cases for

the total population, this will result in an attack rate of 3.5 per cent of the total population.

The incidence of male and female asthmatic attacks by parish is given in a GIS plot in Figure 6. This shows the
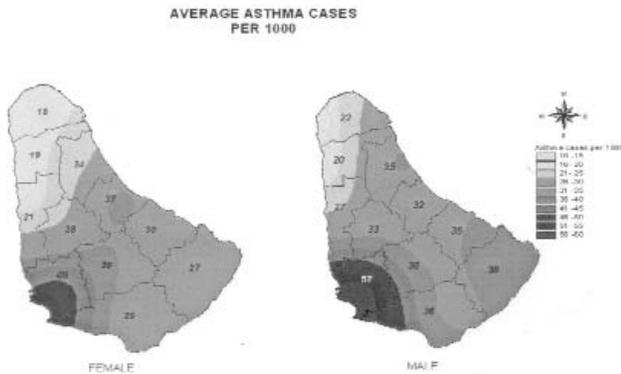
Fig. 6: The gender distribution of asthma cases by parish.

generally higher incidence for males than for females in each parish.

Figure 7 is a plot of the asthmatic cases ranked by age, in five-year segments for the years 1996, 1999 and 2002 and
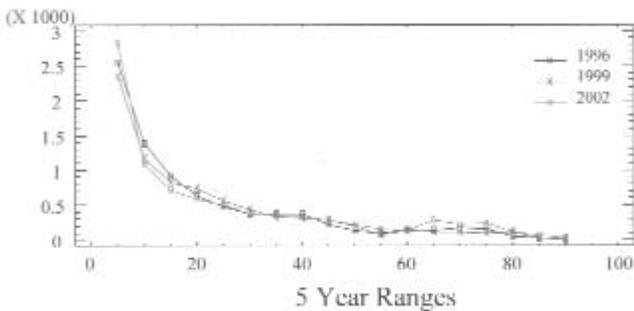
Fig. 7: The number of asthma cases in 5-year periods for the years 1996, 1999, 2002.

Figure 8 represents the nine-year average (1996–2004). All of the years had a similar distribution curve. Statistical tests
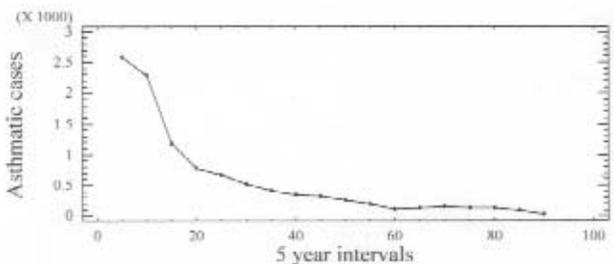
Fig. 8: Number of asthma cases in 5-year intervals for the 9-year average (1996–2004).

showed that this curve had an exponential form. In addition, if we sum the first three segments 0–15 years, this represents an attack rate of 58.4% of the total attacks.

The statistical analysis of the data uses St George's asthmatic cases only. Simultaneous correlations (Table 2)

Table 2: Correlation coefficients of the number of asthma cases with relative humidity – RH, vapour pressure – VP, wind speed – WS, average temperature - $\bar{T}$ and rainfall -Rain

Variables	RH	VP	WS	$\bar{T}$	Rain
Coefficients	0.48	0.54	-0.41	0.14	0.36

were obtained between the asthmatic cases and the meteorological variables using the five-term running averages with rainfall restricted to St George's stations only.

Figure 9 is a plot of the time series and the five-term running averages for the rainfall and the vapour pressure. It

a.

b.
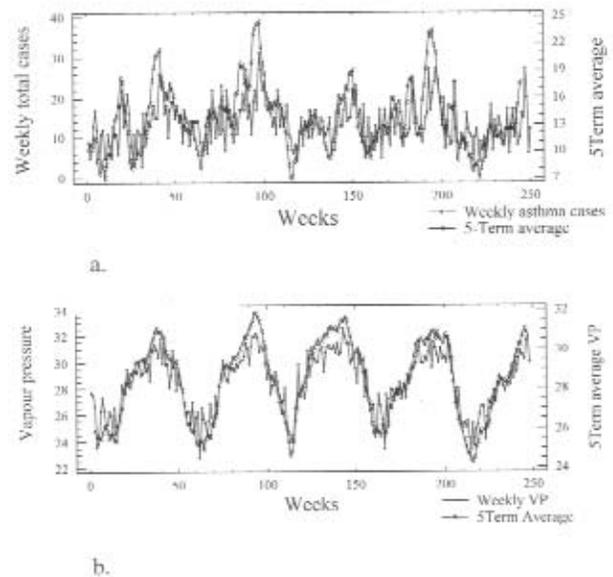
Fig. 9: Time series and 5-term running averages of (a) weekly asthma cases and (b) weekly average vapour pressure, 1996–2000.

is evident that the averaging process reduces some of the variability in the data.

Table 2 shows that the highest correlation $r = 0.54$ was found with the vapour pressure and Figure 10 is a plot of the fitted line. Although this may be considered a moderate
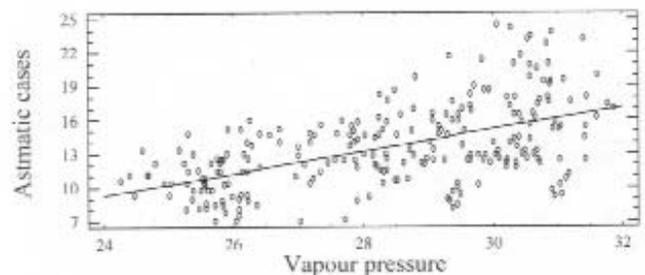
Fig. 10: Fitted line of 5-term running averages of weekly asthma cases and vapour pressure.

association, it is significant at the 99% level ($p = 0.000$) and gives an explained variance of 29.2 %.

A cross-correlation analysis using the five-term running average of the asthmatic cases and the vapour pressure was used to determine any significant lag relationships between these variables. Figure 11 shows that the maximum
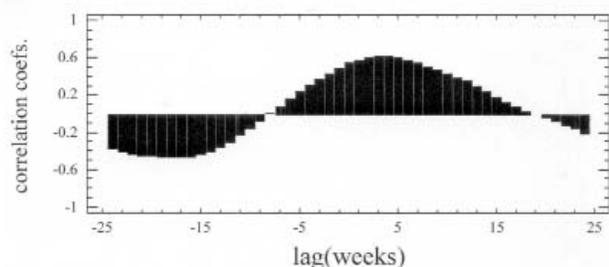
Fig. 11:   Cross-correlation coefficients between asthma cases and vapour pressure.

coefficient $r = 0.61$ occurs at lag of three weeks with a slightly lower value at a lag of four weeks.

A spectral analysis (Fig. 12) was carried out on the asthma data to determine the major periodicity in the data.
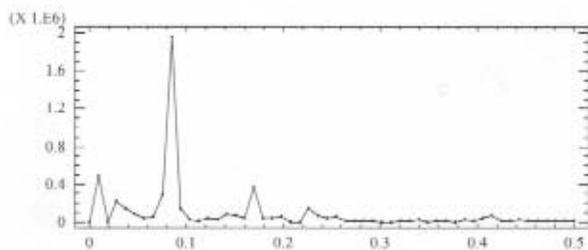
Fig. 12:   Spectral density of the asthma data.

The figure shows that the maximum peak occurred at a cycle of about 12.5 months.

A step-wise regression analysis using all the meteorological variables resulted in the following equation: Asthmatic cases = $11.66 - 11.15\bar{T} + 1.28$ VP; where $\bar{T}$ is the average temperature and VP is the vapour pressure.

DISCUSSION
This study has established the demographic distribution of asthma cases in Barbados. The populations of the eleven parishes have a minimum of 5613 in St Andrew and a maximum of 91 025 in the urban parish of St Michael. Figure 1 shows that the incidences of the asthma cases are higher in the parishes with eastern coastlines than in those with western coastlines with the exception of St Michael. This may be due to the higher saline aerosol that impacts the eastern coastlines and the resulting allergic reaction to the salt particles. The higher number in St Michael may be attributed to higher levels of pollution, poor ventilation because of the close proximity of the houses and higher exhaust emissions

from vehicles. It is also evident that the eastern parish of St Andrew (population 5613) has a higher incidence than its neighbouring parishes of St Peter (population 11 405) and St James (population 24 270).

The distribution, as given for the "asthmatic year", shows that there is a minimum number of asthmatics in April and that there are generally increasing values to a maximum in October followed by steadily decreasing values to March. We view this as a better presentation than the use of the calendar year which fails to suggest that the January to March values are simply part of the decreasing values to the April minimum.

The distribution of the asthmatic year coincides with the distribution of the rainy season which normally begins in May, reaches its maximum in October and decreases steadily thereafter to the dry season (January to April). It is during the rainy season that there is an increase in molds, spores, pollen and other chemical aeroallergens in the atmosphere. Many of these are imported into the island from Africa and Europe through the atmospheric circulation patterns (14). These will exacerbate the effects of the house-dust mite shown to be significant in asthmatic attacks (9). It is also generally believed that there is a relationship between the outbreaks of African dust and asthmatic attacks. These outbreaks originate in Africa and are largest during the May to November period. The dust has been shown to contain spores and pollen and other particles from biomass burning in Africa.

The distribution of the annual asthmatic cases as shown in Figure 3 differs from that in the earlier study (10) which clearly showed an annual increase in the number of asthmatic cases. For the period under study, with the exception of 1997, the numbers appeared to have stabilized with an annual average of 10 348 cases.

The slight variation of the incidence of about 4.8% of attacks in St Michael (Table 1) during the period under study is significant. During this period, the number of vehicles in Barbados increased from 55 000 in 1995 to 110 000 in 2005. This has resulted in major traffic congestion with high levels of exhaust emissions in St Michael. This would have been expected to result in higher levels of asthmatic attacks. We hypothesize that this expected result did not materialize as a result of the change to the use of only unleaded gasoline in Barbados in 1998. This would have resulted in the absence of some lead-related chemical aeroallergens.

The gender distribution of asthmatics as seen in Figure 4 shows that there is a higher incidence of asthmatic attacks in males than in females in each parish, although there are more females than males in each parish, with the exception of St Andrew. This shows that approximately 3% of females and 4% of males suffer attacks. This may be due to the fact that males are more exposed to allergens through greater participation in outdoor activities. Asthma is therefore more likely to occur in males than in females. The incidence (per thousand) is shown in Figure 5. The figure shows a higher

incidence for males in all parishes except for the parish of St Joseph.

The ranking of the asthma cases by age shows that similar patterns occur for each year. The curves also indicate that there is an exponential decrease in asthmatic attacks with age. It is evident that the highest number of attacks occurs in the less than five-year age group and suggests that many children become free of asthma by age 15 years. Children and adolescents under the age of 15 years account for nearly 60% of all asthmatic attacks.

The effects of the meteorological variables were determined by statistical analysis. The highest correlation occurred between the asthmatic attacks and the vapour pressure which is a better measure of atmospheric moisture than relative humidity. Although there are significant correlations with the other variables, these are themselves highly correlated with the vapour pressure. It can be concluded, however, that atmospheric moisture plays a significant role in the initiation of asthmatic attacks. The cross-correlation analysis, which accounts for the delay between the occurrence of the meteorological event and the presentation of the asthmatic attacks, showed that there is a maximum lag of three to four weeks between the vapour pressure and the asthmatic attacks. This suggests that although there may be some immediate reaction to increased moisture in the atmosphere, due to rainfall, the greatest effects occur three to four weeks later.

The spectral density shows that the period associated with the asthmatic attacks is about 12.5 months. This period is close to that of the vapour pressure (50 weeks).

The multiple regression analysis provides a predictive equation which explains 34.4% of the variance. It should be noted that the equation does not include a term to account for the other factors that may result in asthmatic attacks, and consequently, may be limited in its use. The inclusion of the relative humidity in the equation increases the variance by about 2%. This small change is to be expected since the vapour pressure and the relative humidity are highly correlated. In addition, it was significant at the 90% level and was therefore omitted.

It is hoped that the demographic information and the statistical analysis presented in this study would be of interest to clinicians in Barbados and that it adds to the body of knowledge associated with this disease.

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