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Article type : Research Letter

Annual hospitalisation rates for children with asthma are inversely associated with total hours of sunshine in English regions

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To the editor -

During childhood, exacerbation of asthma is the most common medical reason for admission to hospital in the UK. Each year 44,000 children are admitted to hospital in the UK with 40-50 children dying as a result of asthma [1].

Weather patterns and seasonality have distinct, measurable effects on the rates of hospitalisation for asthma. Short-term severe weather events such as thunderstorms are known to have an impact upon emergency admissions with asthma [2]. Acute asthma admissions are also subject to considerable seasonal variation with numbers peaking in the UK between September and December [3]. Long-term weather patterns have been shown to have a small effect on prevalence of childhood asthma [4] but the effects of longer-term weather patterns on hospital use or asthma control have not been studied.

As the total hours of sunshine in any year within a region of the UK represents the amount of non-dietary vitamin D available to the population we hypothesised that if vitamin D is an important determinant of severe asthma exacerbation then there would be a relationship between annual hours of sunshine and asthma and hospital admissions for asthma. By using annualised data we were able to partially correct for known effects of seasonality on asthma admission. Other devolved nations within the UK were excluded as comparable admission data were not available.

The primary aim of this study was to determine whether there was a relationship between annual hours of sunshine and asthma morbidity (as measured by age-gender corrected asthma admission rates) in six distinct geographic regions within England. Secondary aims were to determine whether there were also associations between latitude and crude childhood deprivation indices and whether these strengthened or weakened any observed association.

Methods

Raw data for the total HOS in each region of the UK were obtained from the UK Met Office [5]. We calculated the total HOS for nine consecutive years between April 2002 and March 2011 in six discrete meteorological regions (<http://www.metoffice.gov.uk/climate/uk/about/districts-map>). These regions were used to define the boundaries for hospital admission data. The central point in each region was used to determine longitude and latitude.

We used Hospital Episode Statistics (HES) data to determine the annual (April 1st – March 31st) age-gender corrected rates of all non-planned (emergency) hospital admissions for childhood asthma between April 2002 and March 2011 [6]. We included all non-planned admissions of children (<16 years) with a principal diagnosis of asthma based upon an International Classification of Diseases (10th Revision), code J45 (asthma) or J46 (acute severe asthma). Emergency asthma admission rates per 100,000 population were obtained for the multiple Primary Care Trust areas corresponding to the six meteorological areas.

We used the Income Deprivation Affecting Children Index 2010 (IDACI) as our marker of socioeconomic deprivation as this directly applies to children [7]. IDACI was obtained for nine UK regions. Three of these mapped consistently with our weather regions. Composite indices for the other regions were imputed by combining data from two regions with population weighting.

Data for hours of sunshine and hospital admission rates were assessed for normality using graphical visual inspection and the Shapiro-Wilk test. Correlation analysis was performed to assess the relationship between annual HOS within a Met Office region and the asthma admission rate using Spearman's Rank-Order Correlation. To determine the best model to predict age-gender corrected hospital admission rates for asthma we used forward stepwise multivariable linear regression with an exclusion parameter of $p > 0.1$. We initially included all available data: HOS, year, longitude, latitude and IDACI. Statistical analyses were carried out using STATA version 12.0 (STATA Corp, Texas, USA).

Results and discussion

Over the 9-year study period 220,913 children were admitted to English hospitals with an exacerbation of asthma. The estimated population of children studied varied from a minimum of 9,654,027 in 2007-8 to a maximum of 9,853,580 in 2002-3. The year with the highest number of admissions was 2006-7, when there were 26,979 admissions. The following year saw the lowest number of asthma admissions, with 22,751.

The region with the lowest mean (SD) age-gender corrected asthma admission rate was "England South-East & Central South" with 214.9 (19.4) admissions per 100,000 per year and the region with the highest was "England North-West & North Wales" with 373.3 (32.9) admissions per 100,000 per year. Figure 1A illustrates HOS and hospital admission rates averaged over nine years for the six Met Office regions. It shows a tendency for admission rates to be lower in regions with higher annual HOS. The scatterplot of total annual HOS plotted against emergency hospital admissions for childhood asthma in each of the six Met Office regions is presented in Figure 1B.

A stepwise linear multiple regression analysis was performed. Using this unsupervised approach, a model was generated which included HOS, latitude and socioeconomic deprivation. Longitude and year of study were dropped in this model (see Table 1). The adjusted R-squared value for this model was 0.5574.

Age-gender corrected asthma admission rates reduce by 21 per 100,000 children for each additional 100 HOS in each region. This is an important effect in both real and relative terms. In 2010-11 the age-gender corrected admission rate for asthma was 233 admissions per 100,000 children in England. It is unlikely that the observed effect is the result of variation in asthma prevalence alone as it is relatively large and bigger than that previously reported (around 1% for every 100 additional HOS) [4].

There is significant observational evidence to suggest that vitamin D is important in determining the frequency and expression of asthma in children [8-10]. However, it is plausible that children with more severe or symptomatic asthma have lower vitamin D levels because they are less able or willing to play outdoors. Time outdoors is particularly important in determining vitamin D levels as diet accounts for only a small proportion (10%) of vitamin D intake for most UK children. The vast majority is produced following exposure of the skin to UVB radiation (290–315 nm).

By adopting a whole-population approach in this study we were able to control for this potential confounder as HOS within a region provides an indirect marker of total *available* vitamin D for a population of children. By analysing data by region and by year we are able to partially correct for the known effects of deprivation and seasonality.

However, our study has several important limitations. A whole-population approach has significant advantages (notably size) however it lacks the granularity required to correct for individual confounders including personal vitamin D status, ethnicity, obesity, environmental cigarette exposure and medication use. Moreover, we were not able to analyse the weather data provided in order to correct for hours of sunshine by time of day. Finally, we did not attempt to control for daily temperatures or rainfall as these are significantly correlated with latitude and HOS which were included in our hypothesis-driven model. Therefore any estimates of effect size are, at best, crude.

Nonetheless, by taking a consolidated approach to the data we demonstrated a marked statistical association between HOS and hospital admissions for asthma in English children strengthening the case for intervention studies.

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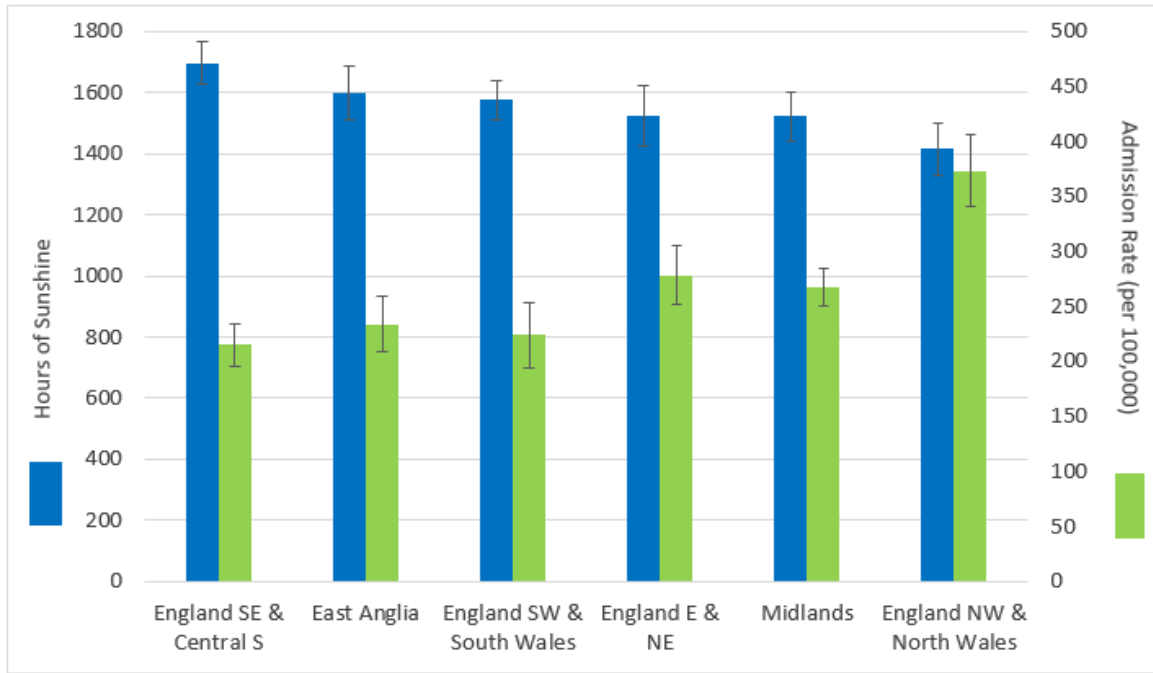
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Acknowledgements and contributions of the authors to this work: WC conceived the initial hypothesis and with AS undertook an outline analysis of weather patterns and asthma admissions. Following helpful suggestions from colleagues BD took the raw data and combined data sets to ensure that weather and hospital admission data were matched. FG contributed to the clinical interpretation of the data and discussion. WC, FG and BD jointly undertook a detailed statistical analysis of the data.

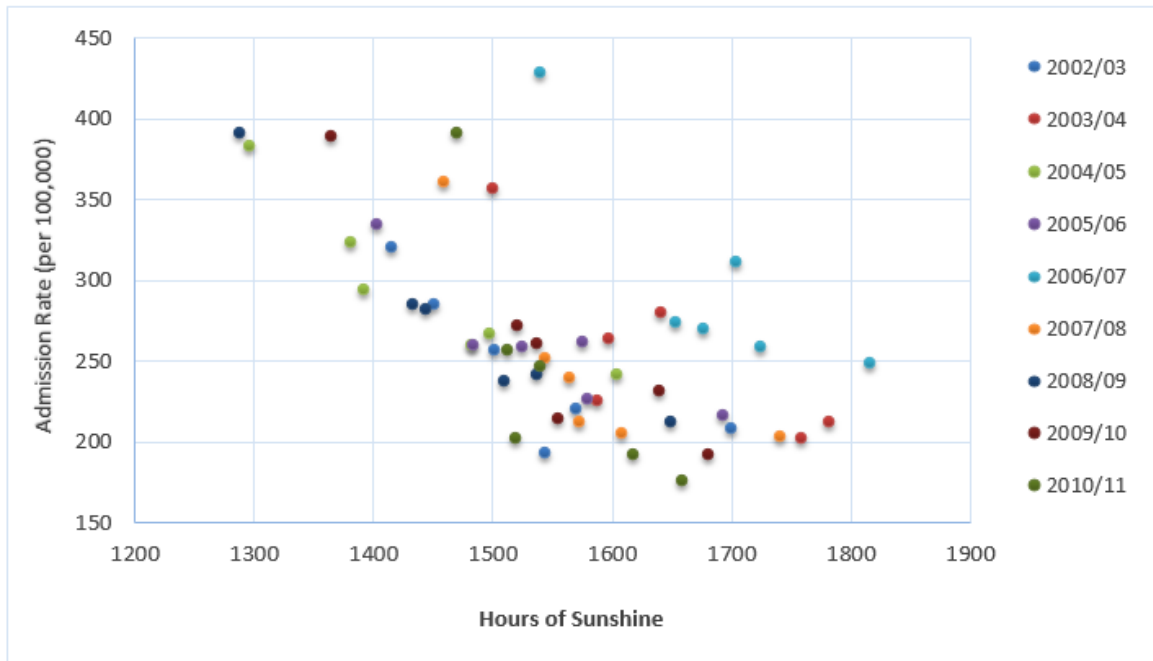
Variable	Admission Rate		
	<i>RC</i>	<i>95% CI</i>	<i>P value</i>
HOS ^a	-0.21	(-0.32, -0.10)	< 0.001
Latitude	21.95	(9.03, 34.87)	0.001
IDACI ^b	3.70	(0.75, 6.65)	0.015

^a Hours of Sunshine ; ^b Income Deprivation Affecting Children Index

Table 1. Regression coefficients, 95% CI and level of significance following multiple regression analysis of rates of emergency hospital admission rates per 100,000 for childhood asthma.



A



$r = -0.651$; 95% CI (-0.782 to -0.464)

B