Spatial and Temporal Analysis of Bronchiolitis in England & Wales, 2004-2010

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KEYWORDS: Respiratory disease; Spatial analysis; Temporal analysis; Area deprivation; Geodemographics

1. Introduction

Infectious diseases have received much attention within the past two decades with outbreaks of acute respiratory infections emerging as one of the top six diseases that are responsible for at least 90% of mortality in children (World Health Organisation 1999). Some health threats have emerged for the first time and caused heavy demands on health administrative systems to deal with their incidence and control their recurrence. Shadowed by the newness of these are other infectious respiratory diseases which also require consideration since there is a constant ebb and flow of occurrences which not only introduce periodic distress in the underlying population, but also added burden on health systems. Usually, when there is a health threat, priority concern is directed at the vulnerable, especially paediatric or geriatric cohorts accessing health care.

Spatial analysis in epidemiology is critical to highlighting and understanding the aetiology of host/environment interaction (Walsh and Jarvis 1992), but investigating the geography of disease may also aid the evaluation of the impact on relevant support systems. Bronchiolitis and pneumonia can both result from infection from the pathogen Respiratory Syncytial Virus (RSV) (Crowcroft *et al.,* 1999; Greenough *et al.,* 2001). This research explores relationships between bronchiolitis occurrences and temperature variation and elements of clustering and dispersion across area deprivation and geodemographic area types. Examining the temporal density of the occurrences of bronchiolitis for young children within a spatial framework should reveal whether Paediatric Intensive Care Units have the capacity to cope with the burden of the disease. This study therefore aims to determine whether:

- Seasonal patterns of bronchiolitis epidemics display distinctive onset and peak timings each year in relation to temperature changes;
- Onset and peak periods are experienced similarly in areas of different levels of deprivation or of different sociodemographic characteristics;
- Paediatric intensive care units have adequate bed space to handle the burden of this disease at onset and peak periods.

2. Data sources

This study uses data obtained from Paediatric Intensive Care Units (PICUs) for June 2004 to May 2010 and focuses on occurrences of bronchiolitis among children aged less than two years of age admitted to PICUs across England and Wales. Individual cases of bronchiolitis are linked at source to Census Lower Super Output Areas and, to aid analyses by area characteristics, the area's level of

relative deprivation and ONS classification geodemographic type. Cases are also linked to individual PICUs so that the location of care can be analysed in relation to distance from residential area. Temperature data have been provided by the UK's 'Met Office' (Met Office 2011).

3. Headline findings

Clear patterns of bronchiolitis intensive care unit admissions for children aged less than 2 years of age are revealed for the 2004-2010 period (Figure 1) with consistent onsets and peaks each year in the study period. This pattern mirrors a systematic decline pattern in temperature during the winter season (Figure 2). These findings are consistent with earlier studies establishing onset and peak time points but strikingly we identify that a *forward* shift in time from a peak in February (Clarke *et al.,* 1978) to a peak in January (Crowcroft *et al.,* 2008) has *continued* with the peak now in December. Since the Met Office (2011) provides a forecasting service to support climatic related health concerns (Maheswaran *et al.,* 2010) there is potential for developing a specific early warning system for bronchiolitis.

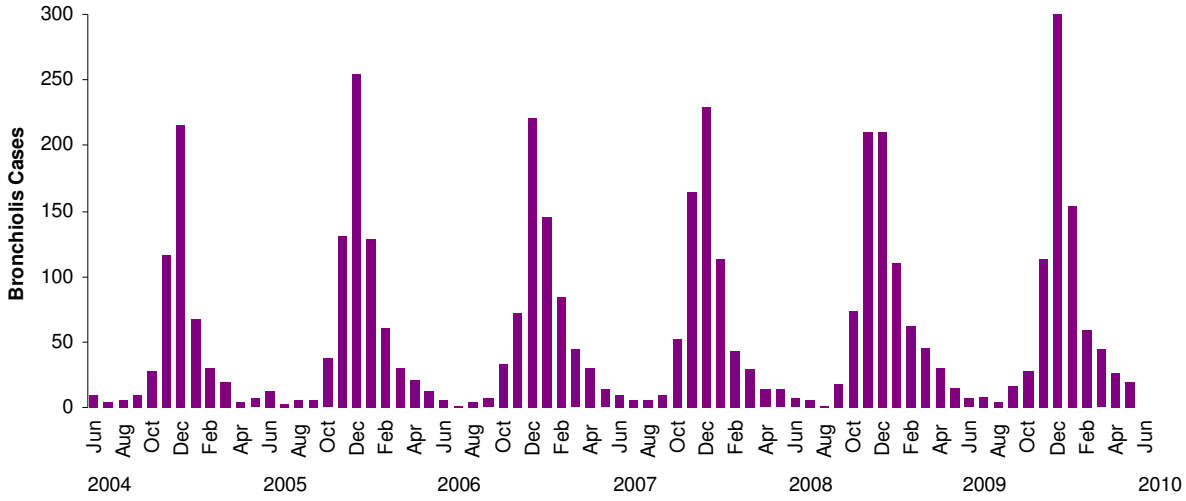


Figure 1. Bronchiolitis admissions per month for England and Wales 2004-2010

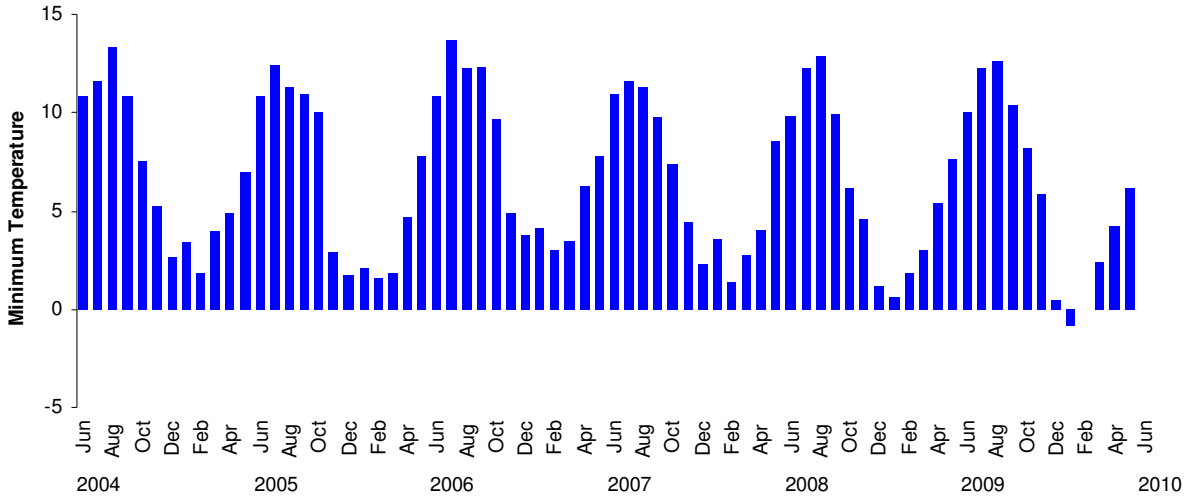
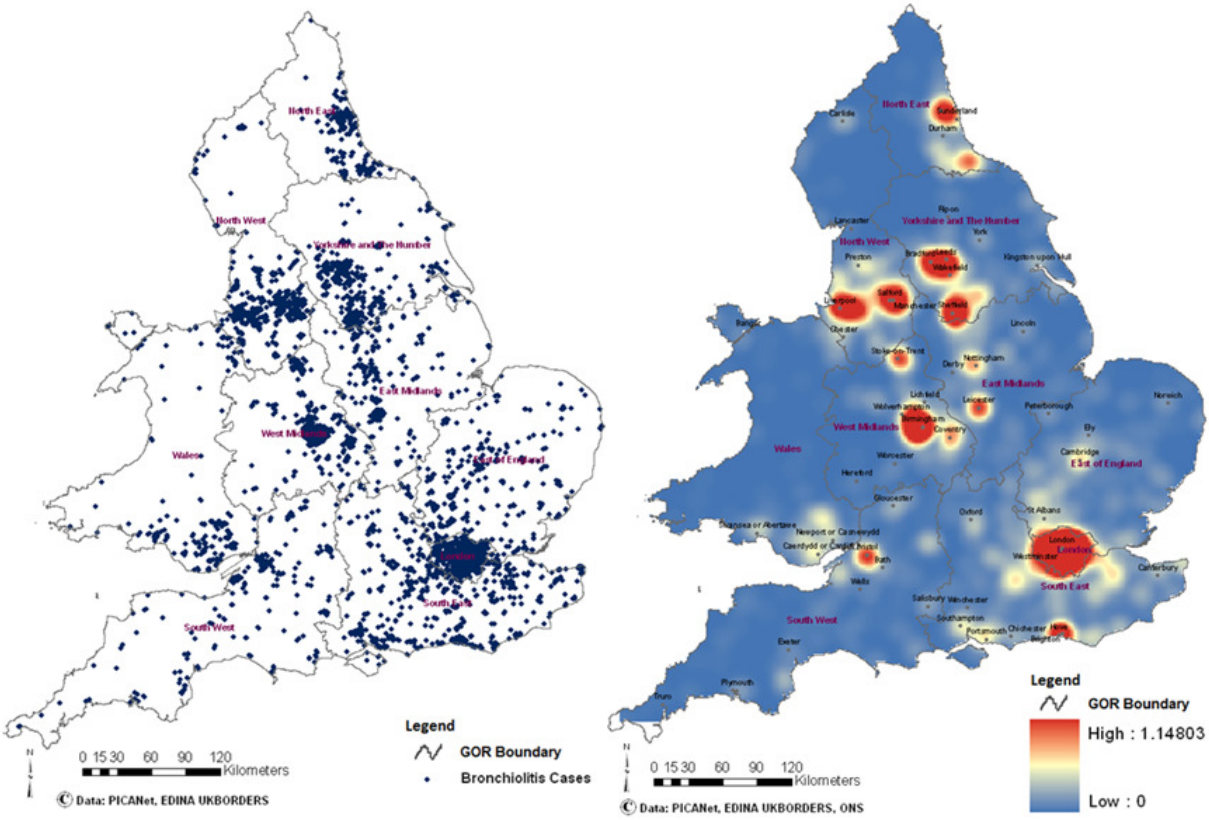


Figure 2. Average minimum temperature per month for England and Wales 2004-2010



a.) Bronchiolitis occurrences, 2004-2010 b.) Kernel density pattern for bronchiolitis 2004-2010

Figure 3. Bronchiolitis distributions, England & Wales, 2004-2010

Figure 3a illustrates the point distribution of bronchiolitis cases for children aged less than two years of age. These appear to be mainly in the more urban areas. Controlling for background population distribution, Figure 3b shows the kernel density estimation risk surface for bronchiolitis which suggests that the more densely populated areas have higher risk.

In terms of geographical impact, the disease onsets are found to be focused in more deprived, urban areas (where epidemic peaks are higher) but with diffusion towards more rural, less deprived areas slightly later (but where peaks are lower). Within urban areas, population subgroups are not affected evenly with prevalence highest in the 'Multicultural', 'Blue Collar' and 'Constrained by Circumstances' groups. Even though located in urban areas, the more professional 'City Living' populations are less affected.

Focusing on the peak of bronciolitis epidemics when PICUs may be under most pressure, there is little by way of a match between the size of the bed capacity of Paediatric Intensive Care Units and the number of cases admitted, whether or not these cases attend the nearest PICU. Five out of the twenty-one PICUs had the number of cases within plus or minus 5% of their capacity but, as Figure 4 shows, eight had spare capacity (the right hand side of the graph) and two were punitively overburdened (left hand side). Figure 5 demonstrates that the largest unit (with 32 beds) was taking cases which were not the nearest unit to the patient but was still below capacity. However, the over-capacity PICUs were also taking non-local patients. Clearly these mismatches need further investigation in space and time. A further data download has been requested.

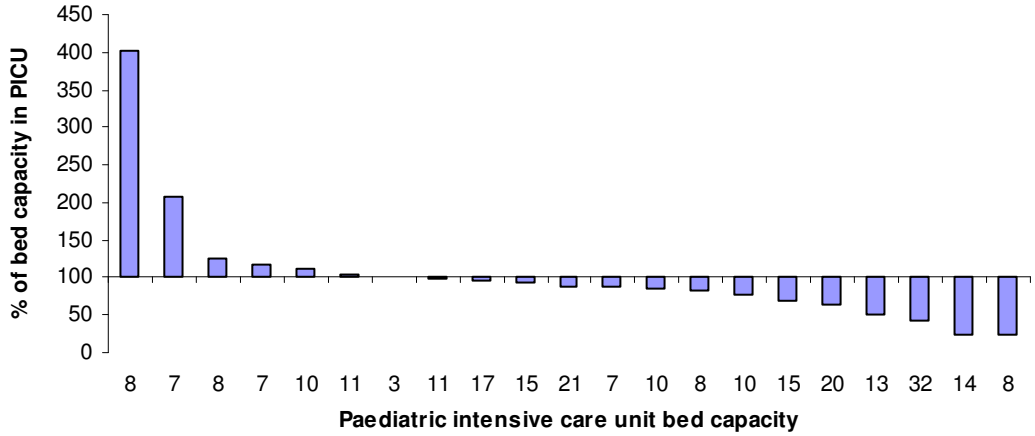


Figure 4. Number of admissions as a percentage of bed capacity at epidemic peak

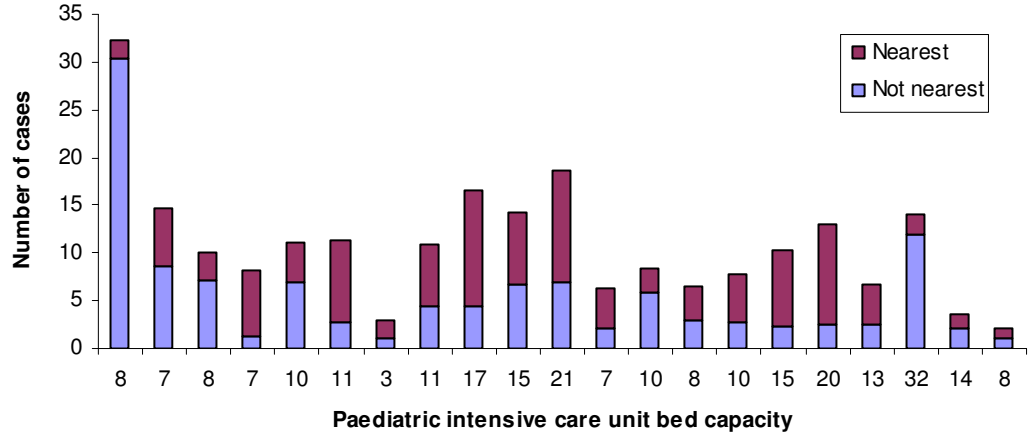


Figure 5. Bed capacity by whether the nearest PICU was attended at epidemic peak

4. Conclusions

Overall, this work aimed to establish whether temporal patterns previously found still exist and whether there are distinct spatial patterns for bronchiolitis across the urban-rural and deprivation gradients and in sociodemographic strata in the population of England and Wales. In an applied setting, this research sought to determine whether paediatric intensive care facilities are currently equipped in terms of bed space to deal with demands for admissions at onset and peak periods in the bronchiolitis season. The seasonality of onset and peaks has come forward in time compared with previous research with the peak now occurring in December.

The burden of bronchiolitis on PICUs was evaluated to reveal that at the onset of a bronchiolitis epidemic there are almost as many cases accessing units further away as those accessing nearest intensive care units. At the epidemic peak, *more* cases were admitted to PICUs further away from the child's residential location than their nearest unit. Some units appear *constantly* overburdened. These anomalies will be of immediate interest to PICUs and present an opportunity for further investigation.

Note to the GISRUK session organisers. This research as reported above is fit for delivery at a conference but is work in progress since various elements have yet to be investigated in detail.

5. Acknowledgements

The authors are grateful to the PICANet Team for providing the data which made this work possible. The research uses 2001 Census, official Mid-Year Estimates and Vital Statistics data on births which have been provided by the Office for National Statistics and GIS digital boundary data by Ordnance Survey. These data are Crown copyright and are reproduced with permission of OPSI. The GIS boundaries have obtained via EDINA UKBORDERS, an academic service supported by ESRC and JISC.

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Biographies

Paul Norman is a Lecturer in Human Geography and manager of an MSc in GIS programme. He is a population and health geographer who has published widely on time-trends in population change, area characteristics change and associated health changes.

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Lynette Akong has an MSc in GIS having studied following the award of a Commonwealth Scholarship. Her research interests include the aetiology and geography of infectious diseases.

Roger Parslow is a Senior Lecturer in Epidemiology with particular interest in the epidemiology of chronic and critical illness in children and health services research and audit. His recent work investigates cancer in children and trends in childhood type 1 diabetes incidence.