

Asthma and poverty

Roberto J Rona

If the UK Department of Health's "Independent inquiry into inequalities in health"¹ had been carried out in the USA, asthma would probably have occupied a prominent place in the document. In Britain a review of the evidence on inequalities did not mention asthma as a health issue related to poverty. Americans review the association of asthma and poverty on a regular basis in the literature.^{2–7} Platt-Mills³ suggested that the link between low social class and asthma was a phenomenon restricted to the USA. Is this perception correct and, if so, why should it be? In reviewing the topic it is appropriate to disaggregate several related but separate components. Poverty may contribute to the aetiology, exacerbation, recognition, and management of asthma (box 1). There is also a historical perspective that needs some consideration. In Britain both coronary heart disease and diabetes mellitus were initially more prevalent among the wealthy, but subsequently became associated with poverty. Studies based on more recent data may therefore show a different association between asthma and poverty than earlier work.

- As an aetiological factor.
- As a factor contributing to the exacerbation of the condition.
- As a determinant of the quality of care that patients receive.
- As a contributor of psychosocial behaviour which in turn impacts on the management and prognosis of the condition.
- As a component in the labelling of the condition.

Box 1 Possible effects of poverty on asthma

Measuring poverty

The nature and intensity of poverty differ between societies. In the USA financial barriers may prevent the poor from obtaining appropriate care and may limit the ability to purchase medication. In Britain financial barriers are less obvious and cultural differences between strata in society may be more relevant. It is important to consider whether we are dealing with structural poverty—that is, characteristics that are essential to being poor—or characteristics that are associated with the poorest groups in a country. Smoking, high indoor and outdoor pollution, obesity, family size, low birth weight and preterm delivery, characteristics of diet and ethnic background which, in varying degrees, have been found to be related to asthma, are also associated with poverty, but they are not essential conditions of being poor. Poverty has been measured in a variety of ways

in the papers published—namely, income, socioeconomic status (SES), education, housing tenure, quality and amenities, and indices based on an array of social characteristics of small areas such as the Townsend score (UK), small area zip code (USA), or NZDep91 (New Zealand). In the USA education level and income are more frequently used to assess poverty while occupational social class is more widely used in Britain. In both countries small area indicators of poverty have been used in ecological analyses with increasing frequency. Occupational social class of a person is based on his or her job title, the type of work he or she carries out, the training or qualification required for the job, the type of organisation employing him or her, the person's position in the organisation, and whether he or she is self-employed or working for an employer. In Britain occupational social class is usually divided into six groups: professional occupations (I), managerial and technical occupations (II), skilled occupations subdivided into non-manual (III NM) and manual (IIIM), semi-skilled manual occupations (IV) and unskilled manual occupations (V). In most other countries considered in this review measurements of SES have some similarity to the British social class classification.

Ethnic background in most countries is associated with poverty and SES. Black and Hispanic subjects in the USA, Maoris and Pacific Islanders in New Zealand, and black subjects and those originating in the Indian subcontinent in the UK belong mainly, but not exclusively, to the poorest strata of their respective societies. Much of the literature is coloured with attempts to distinguish between the biological, cultural, and social effects of ethnicity on asthma. This overlap will be unsatisfactorily resolved in any single epidemiological study. However, it is telling that in most societies where the phenomena have been studied, asthma is a serious health problem in most socially underprivileged ethnic minorities. In this overview, which is not a systematic review, possible confounders in the association of poverty and asthma are not analysed in depth. In most papers age, sex, and active or passive smoking have been taken into account in the analysis. Air pollution, obesity, family size or birth order, diet, and type of fuel have been included infrequently. The emphasis in this overview is therefore on whether there is an association between poverty and asthma, and less on whether it can be explained by confounders.

The overview that follows is divided into two sections. The first reviews the contribution of poverty to the aetiology of asthma and the second assesses the contribution of poverty to the

Department of Public Health Sciences, Guy's, King's and St Thomas' School of Medicine, Guy's Campus, 6th Floor, Capital House, 42 Weston Street, London SE1 3QD, UK
R J Rona

Correspondence to:
Dr R Rona

severity and exacerbation of the condition. In trying to disentangle effects in the causation of the disease and in its severity there are grey areas that overlap. In many instances the same environmental factors (smoking, sensitisation, housing conditions, and air pollution) may appear as relevant factors in the causation and exacerbation of the condition. Studies based on community studies will be used for assessing the role of poverty in causing asthma. Analyses based on hospital admissions or casualty attendance will contribute to an assessment of the relation between poverty and exacerbation of the condition.

Poverty as a contributor to the aetiology of asthma

ASTHMA AND POVERTY

Mielck and colleagues reviewed 22 studies in children undertaken between 1973 and 1994 and found little consistency in the relation between SES and asthma as ascertained by administered or self-administered questionnaires in community studies.⁸ All the studies were carried out in an English speaking country, mainly in the USA and Britain. Most of the studies showed no association, but most of those which focused on children with severe asthma showed that this was associated with lower SES. In their own study Mielck *et al* also found that poverty and severe asthma were associated in Germany, but this association did not hold for less severe forms of asthma.⁸ Papers published since have not greatly changed this outlook. Another two reports showed that persistent wheeze was more frequent in the socially underprivileged.^{9,10} However, others have been unable to demonstrate an association between asthma and housing tenure,¹¹ income and mother's education,¹² and social class.^{13,14} It is possible that some of the inconsistency in the evidence may be because the association between social class and asthma has changed over a period of 20 years. This has been shown in an analysis based on three surveys using the same design. In the latest survey asthma occurred more frequently in subjects of social classes IV and V, regardless of severity.¹⁵

Asthma is more prevalent in black children living in inner city areas,¹⁶⁻¹⁸ but also in black children not living in poverty in the USA.¹⁹ Thus, the association of ethnicity and asthma cannot entirely be attributed to poverty. In Hispanic subjects the prevalence of asthma is also high, but the frequency of asthma is highest in Puerto Ricans and less so in Mexican and Cuban children.²⁰ It is possible that the differences in the frequency of asthma between Mexican, Cuban, and Puerto Rican subjects in the USA result from differences in social stratification between Hispanic nationalities. Cubans enjoy a higher standard of living than the other Hispanic groups in the USA.

Airway responsiveness was assessed in relation to social background in two studies. In Canada exercise induced bronchoconstriction was highest in poorer social groups but wheeze and diagnosed asthma were not.²¹ In New Zealand and Australia airway responsiveness was

unrelated to SES, but it was higher in children of European descent than in Maoris and Pacific Islanders.²²⁻²⁴ In Zimbabwean children reversible airways obstruction, as assessed by exercise challenge and salbutamol, had a lower prevalence in poor than in wealthy children in an urban setting, and a higher prevalence in an urban than in a rural area.²⁵

There are fewer reports on the relation between poverty and asthma in adults, but most of them indicate an association with a higher prevalence in poor SES groups.²⁶⁻²⁸ Eachus *et al* documented an association between asthma and the Townsend score in women only in a survey that included the assessment of a large number of conditions in Somerset and Avon.²⁹ In the Health Survey for England in 1996 wheeze in the previous 12 months was higher in manual social classes than in non-manual social classes in both sexes. Doctor diagnosed asthma was associated with lower social class in women but not in men.³⁰ In the 1995 survey ever wheeze with breathlessness was unrelated to social class,³¹ but waking at night with an attack of wheeze, a measure of severe asthma, was higher in social class V than in any other social classes (G Valdivia, S Shaheen, personal communication). Some of the reports commented on the difficulty of separating asthma from chronic obstructive pulmonary disease (COPD) in adults,^{27,32} especially in older age groups.³² COPD is strongly associated with social class³³ and misclassification may distort findings, especially in older age groups.

POVERTY, ATOPY, AND ATOPIC DISEASE OTHER THAN ASTHMA

Sensitisation to aeroallergens and atopic conditions other than asthma are both associated with asthma. Thus, the association between SES and sensitisation, eczema, and hay fever may help to provide evidence as to whether living in a poor environment is related to asthma. It has been reported that hay fever and eczema are more frequent in higher social classes.^{13,34,35} The Health Survey for England 1995 confirmed that hay fever was associated with high social class, but eczema was not (G Valdivia, S Shaheen, personal communication). Atopy, defined as a positive skin test to at least one of eight allergens, was more frequent in those with a higher education background.³⁶ In Germany it was more common in those living in the wealthier environment of Munich than in those living in the poorer environment in Leipzig.³⁷ In the Health Survey for England 1995 high social class was associated with the level of specific IgE against dust mite IgE but not with total serum IgE (G Valdivia, S Shaheen, personal communication). Allergen skin test sensitisation to cockroach has been shown to be more prevalent in the poorest groups of society in the USA.^{38,39} The National Cooperative Inner City Asthma Study (NCICAS) reported that positive bedroom and kitchen exposure to cockroach was related to sensitisation in asthmatic children.⁴⁰ Those sensitised to cockroach had higher rates of school absenteeism, sleepless nights, hospital admissions and

unscheduled medical visits.⁴¹ Cockroach sensitisation is high in inner cities and poor neighbourhoods in the USA, but the level of cockroach sensitisation in Britain is markedly lower than in the USA.⁴²

Poverty as a contributor to asthma exacerbation and severity

POVERTY AND ASTHMA MORTALITY

Most of the studies have shown that asthma mortality is higher in ethnic minorities and the poor in the USA^{43–46} and, with less consistency, in Britain.^{47–49} Higgins and Britton⁴⁸ showed an increase in asthma mortality rates in low social classes in 35–65 year old subjects but not in younger groups. Charlton *et al*⁴⁷ found that asthma mortality was one of the few conditions unrelated to poverty, but their study was based on 1974–8 mortality statistics and changes may have occurred since. Although asthma mortality is the most severe outcome, its study can only make a limited contribution to an understanding of the influence of poverty on asthma as death from asthma is a very rare event.

POVERTY AND ASTHMA HOSPITAL ADMISSIONS

Admissions to hospital for asthma are markedly related to poverty.^{5 43 50–55} There are those who have concluded that ethnicity is a more relevant factor than poverty in explaining rates of hospital admissions because adjustment for income did not eliminate the association between ethnicity and admissions to hospital for asthma.^{56–58} Others who have only looked at ethnicity and hospital admissions found rates higher than expected in ethnic minorities living in disadvantageous conditions.⁵⁹ Gilthorpe and colleagues showed that standardised admission ratios increased with higher Townsend scores (denoting higher degrees of poverty) in all ethnic minorities, but less so in white subjects.⁵⁷ They concluded erroneously that poverty was less important than ethnicity. An interaction between poverty and ethnicity on asthma exacerbation is a more appropriate interpretation, based on their published graph, as the increase in admission rates with greater poverty was less marked in white subjects than in other groups. There has been some discussion as to whether the severity of episodes of asthma hospitalisation varies by degrees of poverty. However, one study has shown that levels of oxygen saturation in hospitalised asthma patients were unrelated to poverty,⁵³ and LeSon and Gershwin also found that, among those admitted to hospital with asthma, young asthmatics requiring intubation were more likely to be unemployed and to have a lower level of formal education than controls.⁶⁰ These studies strongly suggest that the higher hospital admission rates of poorer groups and ethnic minorities are attributable to a higher incidence of asthma exacerbation in these groups rather than to lower thresholds of severity for admission.

Higher hospital admission rates of asthmatics who are poor or belong to ethnic minorities may be due to the fact that these groups rely mainly on crisis management of the condition,^{61–64} are under medicated,^{50 63 66–73} are under-users of primary

care facilities,^{62 66 67 72 74 75} lack a planned crisis management,⁶⁴ live in adverse environmental conditions in terms of asthma triggers such as smoking and cockroach exposure,^{41 50} or are exposed more frequently than other groups to psychosocial problems within the family and their community.⁷⁶ Halfon *et al* reported that, when poor asthmatic subjects are sick, they are four times more likely to attend casualty departments than other asthmatics of similar severity.⁶¹ Others have also reported similar findings.^{45 62–65} A higher attendance rate at the casualty department has also been found in black American subjects compared with white subjects, after adjustment for SES.^{66 67} The higher attendance at the casualty department by black subjects after adjustment for SES has puzzled some researchers. However, one should be cautious with the inference from observational studies that ethnicity is more important than poverty in asthma exacerbations as adjustment for poverty factors is always incomplete.

Under medication, a serious problem in poor areas, either assessed in terms of prescription of steroids or the ratio of steroids to β agonist use, has been well documented in the literature.^{50 63 66 68–73} The lack of a regular source of care is given as a reason for poor management of asthma in the USA.⁷⁵ This has been partially supported by the finding that American Indians and Alaskan natives, entitled to free health care in the USA, have a hospital admission rate similar to white subjects despite the fact that their SES is similar to that of black subjects.⁷⁷ However, these ethnic minorities do not share similar environmental conditions or genes to those of black and Hispanic subjects living in inner city areas. In Britain a group researching hospital admissions for asthma in a deprived area of London concluded that admissions were strongly related to smaller partnership size in general practice.⁷⁸

MANAGEMENT OF ASTHMA IN THE COMMUNITY

It is clear that adherence to medication is lower in poorer groups of the community. The main problem is the low percentage of asthma patients in the poor groups of society who are prescribed an anti-inflammatory drug, as shown mainly in the USA^{66 71 73 79} but also in Britain.⁷⁰ Symptoms of wheeze without a label of asthma are associated in Britain with the poorest rate of medication and wheeze without the label of asthma is more frequent in low SES.⁷⁰ However, even in those with an asthma label in the low SES groups, the percentage receiving an anti-inflammatory drug is relatively low.^{51 62 70 73} Patients of low SES may not value the use of steroids because they do not perceive them offering any immediate relief of symptoms, are time consuming to use, and are expensive.^{69 80} It has also been noted that patients from the poorer sectors of the community have poor communication with their doctors,^{62 69} and that a large proportion of children take responsibility for their own medication or have multiple carers without a single one taking overall responsibility.⁷¹ With exceptions,⁷⁴ it has been shown that most

families had primary care providers,^{62 73 80} but the poor are under-users of primary care facilities.^{62 66 67 72 74 75} However, access to specialist clinics,^{61 66} waiting for an appointment with a specialist,⁶² frequent change of address⁶⁴ or primary health provider,⁷⁵ and poor knowledge about asthma⁶⁴ are identified as problems in the low SES group. In relation to knowledge of asthma in low SES, Wade and colleagues⁸¹ in the NCICAS study in the USA found that carers were able to demonstrate knowledge, but very few were able to apply knowledge when faced with a vignette of a hypothetical situations requiring asthma care. On some occasions the responses were undesirable and potentially dangerous. Warman and colleagues support these findings.⁷³ In their study carers showed poor management skills when asked to describe how they would respond to a hypothetical asthma exacerbation. However, when these hypothetical responses were compared with responses to real events as obtained from clinical notes, it was found that behaviour was better than the replies to the hypothetical situation, although still deficient. This would imply that carers in the low SES might not be as unskilled in managing asthma exacerbations as inferred from artificially created situations.

ADHERENCE TO ASTHMA TREATMENT AND POVERTY

As shown above, it has frequently been reported that anti-inflammatory drugs are under-used for asthma. In part this may be due to inadequate prescription practices. However, there is evidence that compliance with treatment is low in poor sectors of the population with lower education level.⁷² Haas and colleagues showed that, even after immediate hospital discharge, the poorest and least educated group was likely to receive less intensive therapy.⁷³ Less intensive therapy in that study was defined as not being seen by a specialist, not having had a lung function assessment, and not having been prescribed an anti-inflammatory drug. Apter showed that poor adherence to steroids was associated with poor educational level and poor level of communication with the physician.⁶⁹ Celano *et al* found in a sample of low income patients that use of a metered dose inhaler (MDI), estimated from canister weight, corresponded to 44% of prescribed use, a quarter of the carers demonstrated poor technique, and a large number missed appointments.⁸² Bender *et al*, using an electronic device embedded in an MDI cartridge (recording time and date of each dose dispensed), showed that complete adherence to steroids was minimal (3% of days), and approximately 60% of the time either no doses were taken or use was minimal.⁷⁹ Patients overstated claims of adherence as reported in diaries. In their study poor education level and poor display of affection in the family were related to low adherence and greater disagreement between steroid use as assessed by the electronic device data and responses in the diary. This finding is meaningful since, in the NCICAS study, it was shown that approximately 50% of the nine year old subjects took

principal responsibility for the management of their asthma.⁶² Psychosocial factors affecting the management of asthma have been frequently reported. Anderson *et al* reported that adherence was poorer, not only in lower social classes, but also in children who left school before 16 or whose mothers had evidence of depression or anxiety.⁶⁸ Wade⁸¹, assessing the psychosocial tests used in the NCICAS, found that carers of asthmatic children in inner city areas reported very high levels of behavioural problems in their children. Almost 35% had scores compatible with clinical severity. Butz *et al* reported an association between high levels of behaviour problems and severity of asthma symptoms in the group whose parents had low educational background, low SES, and perceived low level of social support.⁷⁶ In describing the psychological status of the carers Wade reported increased levels of psychological distress compared with normative samples.⁸¹ Morgan reported in a qualitative study that much of the non-adherence to asthma medication is related to intentional non-adherence in ethnic minorities from poor neighbourhoods.⁸³ This would imply that education alone may not be a solution to asthma exacerbation and that an understanding of cultural patterns in these groups may be of greater importance.

Given the great complexity of the problem and the variety of issues involved, it is perhaps unsurprising that the results reported in evaluative studies do not show changes in the severity of asthma or in the quality of life of asthmatic subjects. Evaluation of interventions has not been the intention of this review. Education efforts in relation to asthma seem to be successful in changing levels of knowledge,^{84 85} but outcomes such as compliance, hospital admission, days lost from school or work, or attendance at casualty are unchanged.⁸⁴ Eastwood and Sheldon⁸⁶ concluded from their systematic review that there was little good published research on organisational methods of delivery of asthma care and Premaratne and colleagues⁸⁷ failed to show any differences in the use of an asthma resource centre in improving treatment and quality of life. Likewise, intervention to decrease exposure to cockroaches in an inner city environment was largely unsuccessful.⁸⁸

Conclusions

There is a lack of consistent evidence that some aspect of poverty causes asthma or bronchial reactivity. Many possible risk factors for asthma such as smoking, low birth weight, smoking, air pollution, cockroach exposure, and obesity are more prevalent in poor sectors of the community, but hay fever, traits of atopy, and, with less compelling evidence, eczema have a higher prevalence in the less deprived sectors of society. Even in reports in which limited adjustment for confounders were made, the association between poverty and asthma is inconsistent. There are two possible strategies for further progress in this area full of paradoxes. The first is to make progress in the taxonomy of asthma and to carry out analysis

according to subtypes of asthma—for example, if it were shown that the aetiology of severe asthma is different from mild asthma. This is currently not possible in population studies. Alternatively, a systematic review could be carried out. There are many studies available for such an analysis but substantial differences in the measurement of SES and poverty between countries make it difficult.

There is overwhelming evidence that exacerbations of asthma in terms of casualty attendances, hospital admissions, and deaths are related to poverty or to groups that are prevalent in poor sectors of society. It is possible that this assessment is coloured by the predominance of the USA reports in the literature. Tackling the problem is difficult because many factors are involved: environmental exposure, suitability of primary care services, communication skills of health professionals, cultural characteristics of patients and their families, and psychosocial problems related to life events. Effective interventions for tackling exacerbations and severe asthma need to take into account this kaleidoscope of hurdles and opportunities.

I am indebted to Professor Peter Burney and Drs Debbie Jarvis and Seif Shaheen for their comments to early drafts of the paper. I am, however, responsible for all the views expressed in this paper.

- Department of Health. *Independent inquiry into inequalities in health*. Chairman: Donald Acheson. London: Stationery Office, 1998.
- Gergen P. Social class and asthma: distinguishing between the disease and the diagnosis. *Am J Public Health* 1999;**86**: 1361–2.
- Platts-Mills TAE, Carter MC. Asthma and indoor exposure to allergens. *N Engl J Med* 1997;**336**:1382–4.
- von Schlegell A, Grant EN, Weiss KB. The burden of asthma: weighing the community risk against individual risk. *Thorax* 1999;**54**:471–2.
- Sly RM. Asthma in the inner city. *Immunol Allergy Clin North Am* 1991;**11**:103–15.
- Steigman DM. Is it “urban” or is it “asthma”. *Lancet* 1996;**348**:143–4.
- Weiss KB, Gergen PJ, Crain EF. Inner city asthma. The epidemiology of an emerging US Public Health Concern. *Chest* 1992;**101**(Suppl):362–7S.
- Mielck A, Reitmeir P, Wjst M. Severity of childhood asthma by socioeconomic status. *Int J Epidemiol* 1996;**25**:388–93.
- Duran-Tauleria E, Rona RJ. Geographical and socioeconomic variation in the prevalence of asthma symptoms in English and Scottish children. *Thorax* 1999;**54**:476–81.
- Whincup PH, Cook DG, Strachan DP, et al. Time trends in respiratory symptoms in childhood over a 24 year period. *Arch Dis Child* 1993;**68**:729–34.
- Burr ML, Anderson HR, Austin JB, et al. Respiratory symptoms and home environment in children: a national survey. *Thorax* 1999;**54**:27–32.
- Stoddard J, Miller T. Impact of parental smoking on the prevalence of wheezing respiratory illness in children. *Am J Epidemiol* 1995;**141**:96–102.
- Lewis SA, Britton JR. Consistent effects of high socioeconomic status and low birthorder, and the modifying effect of maternal smoking on the risk of allergic disease during childhood. *Respir Med* 1998;**92**:1237–44.
- Lewis S, Butland B, Strachan D, et al. Study of the aetiology of wheezing illness at age 16 in two national British birth cohorts. *Thorax* 1996;**51**:670–6.
- Rona RJ, Hughes JM, Chinn S. Association between asthma and family size between 1977 and 1994. *J Epidemiol Community Health* 1999;**53**:15–9.
- Crain EF, Weiss KB, Bijur PE, et al. An estimate of the prevalence of asthma and wheezing among inner-city children. *Pediatrics* 1994;**94**:356–62.
- Schwartz J, Gold D, Dockery DW, et al. Predictors of asthma and persistent wheeze in a national sample of children in the United States. Association with social class, perinatal events, and race. *Am Rev Respir Dis* 1990;**142**:555–62.
- Weitzman M, Gortmaker S, Sobol A. Racial, social, and environmental risks for childhood asthma. *Am J Dis Child* 1990;**144**:1189–94.
- Nelson DA, Johnson CC, Divine GW, et al. Ethnic differences in the prevalence of asthma in middle class children. *Ann Allergy Asthma Immunol* 1997;**78**:21–6.
- Carter-Pokras OD, Gergen PJ. Reported asthma among Puerto Rican, Mexican-American, and Cuban children, 1982 through 1984. *Am J Public Health* 1993;**83**:580–2.
- Ernst P, Demissie K, Joseph L, et al. Socio-economic status and indicators of asthma in children. *Am J Respir Crit Care Med* 1995;**152**:570–5.
- Mitchell EA, Stewart AW, Pattemore PK, et al. Socioeconomic status in childhood asthma. *Int J Epidemiol* 1989;**18**: 888–90.
- Pattemore PK, Aher MI, Harrison AC, et al. Ethnic differences in prevalence of asthma symptoms and bronchial hyperresponsiveness in New Zealand schoolchildren. *Thorax* 1989;**44**:168–76.
- Peat JK, Britton WJ, Salome CM, et al. Bronchial hyperresponsiveness in two populations of Australian schoolchildren. II. Relative importance of associated factors. *Clin Allergy* 1987;**17**:283–90.
- Keeley DJ, Neill P, Gallivan S. Comparison of the prevalence of reversible airways obstruction in rural and urban Zimbabwean children. *Thorax* 1991;**46**:549–53.
- Littlejohn P, MacDonald LD. The relationship between severe asthma and social class. *Respir Med* 1993;**87**:139–43.
- McWhorter WP, Polis MA, Kaslow RA. Occurrence, predictors, and consequences of adult asthma in NHANESI and follow-up survey. *Am Rev Respir Dis* 1989;**139**:721–4.
- Salmund C, Crampton P, Hales S, et al. Asthma prevalence and deprivation: a small area analysis. *J Epidemiol Community Health* 1999;**53**:476–80.
- Eachus J, Williams M, Chan P, et al. Deprivation and cause specific morbidity: evidence from Somerset and Avon survey of health. *BMJ* 1996;**312**:287–92.
- Prescott-Clarke P, Primates P. *Health Survey for England 1996*. Volume I. London: Stationery Office, 1998.
- Prescott-Clarke P, Primates P. *Health Survey for England 1995*. Volume I. London: Stationery Office, 1997.
- Erzen D, Carriere KC, Mustard C, et al. Income level and asthma prevalence and care patterns. *Am J Respir Crit Care Med* 1997;**155**:1060–5.
- Prescott E, Vestbo J. Socioeconomic status and chronic obstructive pulmonary disease. *Thorax* 1999;**54**:737–41.
- Strachan DP, Taylor EM, Carpenter RG. Family structure, neonatal infection, and hay fever in adolescence. *Arch Dis Child* 1996;**74**:422–6.
- Williams HC, Strachan DP, Hay RJ. Childhood eczema - disease of the advantaged. *BMJ* 1994;**308**:1132–5.
- Forastiere F, Agabiti N, Corbo GM, et al. Socioeconomic status, number of siblings, and respiratory infections in early life as determinants of atopy in children. *Epidemiology* 1997;**8**:566–70.
- von Mutius E, Martinez FD, Fritzsch C, et al. Skin test reactivity and number of siblings. *BMJ* 1994;**308**:692–5.
- Garcia DP, Corbett ML, Sublett JL, et al. Cockroach allergy in Kentucky: a comparison of inner city, suburban, and rural small town. *Ann Allergy* 1994;**72**:203–8.
- Sarpong SB, Hamilton RG, Eggleston PA, et al. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitisation in children with asthma. *J Allergy Clin Immunol* 1996;**97**:1393–401.
- Eggleston PA, Rosenstreich D, Lynn H, et al. Relationship of indoor allergen exposure to skin test sensitivity in inner-city children with asthma. *J Allergy Clin Immunol* 1998;**102**: 563–70.
- Rosenstreich D, Eggleston P, Kattan M, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N Engl J Med* 1997;**336**:1356–63.
- Luczynska CM, Walker LA, Burney PGJ. Skin sensitivity in school children in two different areas of London. *Eur Respir J* 1995;**8**(Suppl 19):350S.
- Carr W, Zeitel L, Weiss K. Variations in asthma hospitalisations and deaths in New York City. *Am J Public Health* 1992;**82**:59–65.
- Corn B, Hamrung G, Ellis A, et al. Patterns of asthma death and near-death in an inner-city tertiary care teaching hospital. *J Asthma* 1995;**32**:405–12.
- Lang DM, Polansky M. Patterns of asthma mortality in Philadelphia from 1969 to 1991. *N Engl J Med* 1994;**331**: 1542–6.
- Malveaux FJ, Houlihan D, Diamond EL. Characteristics of asthma mortality and morbidity in African-Americans. *J Asthma* 1993;**30**:431–7.
- Charlton JRH, Hartley RM, Silver R, et al. Geographical variation in mortality from conditions amenable to medical intervention in England and Wales. *Lancet* 1983;**i**: 691–6.
- Higgins BG, Britton JR. Geographical and social class effects on asthma mortality in England and Wales. *Respir Med* 1995;**89**:341–6.
- Jones AP, Bentham G. Health service accessibility and deaths from asthma in 401 local authority districts in England and Wales, 1988–92. *Thorax* 1997;**52**:218–22.
- Burr ML, Verrall C, Kaur B. Social deprivation and asthma. *Respir Med* 1997;**91**:603–8.
- Gottlieb D, Beiser A, O'Connor G. Poverty, race, and medication use are correlated of asthma hospitalization rates: a small area analysis in Boston. *Chest* 1995;**108**:28–35.
- Lin S, Fitzgerald E, Hwang SA, et al. Asthma hospitalization rates and socioeconomic status in New York State (1987–1993). *J Asthma* 1999;**36**:239–51.
- McConnochie KM, Russo MJ, McBride JT, et al. Socioeconomic variation on asthma hospitalization: excess utilization or greater need. *Pediatrics* 1999;**103**:e75.

- 54 Watson JP, Cowen P, Lewis RA. The relationship between asthma admission rates, routes of admission, and socioeconomic deprivation. *Eur Respir J* 1996;9:2087-93.
- 55 Wissow LS, Gittelsohn AM, Szklo M, et al. Poverty, race, and hospitalization for child asthma. *Am J Public Health* 1988;78:777-82.
- 56 Fox RN, Thamer M, Fadiloglu B, et al. Race, income, urbanicity, and Asthma hospitalization in California. *Chest* 1998;113:1277-84.
- 57 Gilthorpe MS, Lay-Yee R, Wilson RC, et al. Variations in hospitalization rates for asthma among black and minority ethnic communities. *Respir Med* 1998;92:642-8.
- 58 De Palo VA, Mayo PH, Friedman P, et al. Demographic influences on asthma hospital admission rates in New York City. *Chest* 1994;106:447-51.
- 59 Ayres JG. Acute asthma in Asian patients: hospital admission and duration of stay in a district with a high immigrant population. *Br J Dis Chest* 1986;80:242-8.
- 60 LeSon S, Gershwin ME. Risk factors for asthma patients requiring intubation. III Observations in young adults. *J Asthma* 1996;33:27-35.
- 61 Halfon N, Newacheck PW. Childhood asthma and poverty: differential impacts and utilization of health services. *Pediatrics* 1993;91:56-61.
- 62 Crain EF, Kerckmar C, Weiss KB, et al. Reported difficulties in access to quality care for children with asthma in the inner city. *Arch Pediatr Adolesc Med* 1998;152:333-9.
- 63 Dales RE, Schweitzer I, Kerr P, et al. Risk factors for recurrent emergency department visits for asthma. *Thorax* 1995;50:520-4.
- 64 Hanania NA, David-Wang A, Kesten S, et al. Factors associated with emergency department dependence of patients with asthma. *Chest* 1997;111:290-5.
- 65 Kolbe J, Vamos M, Fergusson W. Socio-economic disadvantage, quality of medical care and admission for acute severe asthma. *Aust NZ J Med* 1997;27:294-300.
- 66 Joseph CLM, Havstad SL, Ownby DR, et al. Racial differences in emergency department use persist despite allergist visits and prescriptions filled for antiinflammatory medications. *J Allergy Clin Immunol* 1998;101:484-90.
- 67 Murray MD, Stang P, Tierney WM. Health care use by inner-city patients with asthma. *J Clin Epidemiol* 1997;50:164-74.
- 68 Anderson HR, Bailey PA, Cooper JS, et al. Influence of morbidity, illness label and social, family, and health service factors on drug treatment of childhood asthma. *Lancet* 1981;iii:1030-2.
- 69 Apner AJ, Reisine ST, Affleck G, et al. Adherence with twice-daily dosing of inhaled steroids. Socioeconomic and health belief differences. *Am J Respir Crit Care Med* 1998;157:1810-7.
- 70 Duran-Tauleria E, Rona RJ, Chinn S, et al. Influence of ethnic group on asthma treatment in children in 1990-1: national cross sectional study. *BMJ* 1996;313:148-52.
- 71 Eggleston PA, Malveaux FJ, Butz AM, et al. Medications used by children with asthma living in the inner city. *Pediatrics* 1998;101:349-54.
- 72 Lang DM, Sherman MS, Polansky M. Guidelines and realities of asthma management. The Philadelphia Story. *Arch Intern Med* 1997;157:1193-200.
- 73 Warman KL, Silver EJ, MaCourt MP, et al. How does home management of asthma exacerbations by parents of inner-city children differ from NHLBI guideline recommendations? *Pediatrics* 1999;103:422-7.
- 74 Ali S, Osberg JS. Differences in follow-up visits between African American and white Medicaid children hospitalized with asthma. *J Health Care Poor Underserved* 1997;8:83-98.
- 75 Haas JS, Ceary PD, Guadagnoli E, et al. The impact of socioeconomic status on the intensity of ambulatory treatment and health outcomes after hospital discharge for adults with asthma. *J Gen Intern Med* 1994;9:121-6.
- 76 Butz AM, Malveaux FJ, Eggleston P, et al. Social factors associated with behavioral problems in children with asthma. *Clin Pediatr* 1995;34:581-90.
- 77 Hisnanick JJ, Coddington DA, Gergen PJ. Trends in asthma-related admissions among American Indian and Alaskan native children from 1979-89. *Arch Pediatr Adolesc Med* 1994;148:357-63.
- 78 Griffiths C, Sturdy P, Naish J, et al. Hospital admissions for asthma in east London: association with characteristics of local practices, prescribing, and population. *BMJ* 1997;314:482-6.
- 79 Bender B, Milgrom H, Rand C, et al. Psychological factors associated with medication nonadherence in asthmatic children. *J Asthma* 1998;35:347-53.
- 80 Hartert TV, Windom HH, Peebles RS, et al. Inadequate outpatient medical therapy for patients with asthma admitted to two urban hospitals. *Am J Med* 1996;100:386-94.
- 81 Wade S, Weil C, Holden G, et al. Psychosocial characteristics of inner-city children with asthma: a description of the NCICAS psychosocial protocol. *Pediatr Pulmonol* 1997;24:263-76.
- 82 Celano M, Geller RJ, Phillips KM, et al. Treatment adherence among low-income children with asthma. *J Pediatr Psychol* 1998;23:345-9.
- 83 Morgan M, Olding B. Patient's beliefs and asthma treatment: extending the traditional compliance framework. *Thorax* 1995;50 (Suppl 2):A53.
- 84 Christiansen SC, Martin SB, Schleicher NC, et al. Evaluation of a school-based asthma education program for inner-city children. *J Allergy Clin Immunol* 1997;100:613-7.
- 85 Garrett J, Fenwick JM, Taylor G, et al. Prospective controlled evaluation of the effect of a community based asthma education centre in a multiracial working class neighbourhood. *Thorax* 1994;49:976-83.
- 86 Eastwood AJ, Sheldon TA. Organisation of asthma care: what difference does it make? A systematic review of the literature. *Quality Health Care* 1996;5:134-43.
- 87 Premaratne UN, Sterne JAC, Marks GB, et al. Clustered randomised trial of an intervention to improve the management of asthma: Greenwich asthma study. *BMJ* 1999;318:1251-5.
- 88 Gergen PJ, Mortimer KM, Eggleston PA, et al. Results of the National Cooperative Inner City Asthma Study (NCICAS): environmental intervention to reduce cockroach allergen exposure in inner-city homes. *J Allergy Clin Immunol* 1999;103:501-6.