Eur Respir J 2002; 19: 892–898
DOI: 10.1183/09031936.02.00238402
Printed in UK – all rights reserved

European Respiratory Journal
ISSN 0903-1936

Socioeconomic deprivation and asthma prevalence and severity in young adolescents

M.A. Poyser*, H. Nelson#, R.I. Ehrlich#, E.D. Bateman¶, S. Parnell*, A. Puterman+, E. Weinberg+

Socioeconomic deprivation and asthma prevalence and severity in young adolescents. M.A. Poyser, H. Nelson, R.I. Ehrlich, E.D. Bateman, S. Parnell, A. Puterman, E. Weinberg. ©ERS Journals Ltd 2002.

ABSTRACT: This study used the international study of asthma and allergies in childhood (ISAAC) to investigate the association between asthma and socioeconomic deprivation among young adolescents in Cape Town, South Africa.

The completed ISAAC written and video questionnaires of 4,706 13–14-yr-old school pupils were used. The prevalence of asthma symptoms was analysed by a local index of socioeconomic deprivation, based on residential location and defined on a 10-category scale from least to most deprived. Linear trends were examined visually and the prevalence odds ratio was used to summarize overall trends.

In general, the least socioeconomically deprived pupils reported higher prevalences of asthma symptoms "ever" and "in the last 12 months". In contrast, the most socioeconomically deprived pupils reported higher asthma-symptom occurrence monthly or more frequently in the previous 12 months. A subgroup of pupils from low-income areas commuting to better-off schools showed the highest symptom prevalences.

The findings are consistent with a model in which an increase in the incidence of asthma is driven by factors associated with improved social circumstances, whereas severity is determined by factors associated with poverty. The impact of social mobility on asthma, including reporting of symptoms, deserves closer study.

Eur Respir J 2002; 19: 892–898.

*Dept of Environmental and Geographical Sciences, #Dept of Public Health and Primary Health Care, ¶Dept of Medicine and +Dept of Paediatrics and Child Health, University of Cape Town, Observatory, Cape Town, South Africa.

Correspondence: R.I. Ehrlich, Dept of Public Health and Primary Health Care, Health Sciences Faculty, University of Cape Town, Observatory 7925, South Africa.
Fax: 27 214066163
E-mail: ehrlich@cormack.uct.ac.za

Keywords: Asthma, childhood, epidemiology, socioeconomic status

Received: April 25 2001
Accepted after revision January 17 2002

This study was supported by grants from the South African Medical Research Council and from Boehringer Pharmaceuticals.

The association between the occurrence of childhood and adolescent asthma and socioeconomic status in developed societies has been the subject of contradictory literature. Early studies in Britain and more recent studies in Singapore and Southern China/Hong Kong found the prevalence of parent-reported asthma or wheezing to be greater among subjects of higher socioeconomic status [1–4]. Studies in the USA have tended to find the reverse, *i.e.* a positive association between asthma prevalence and poverty and minority status [5, 6]. More commonly, studies from a number of countries have found no association [7–10]. Studies in poor countries, particularly Africa, have focused on urban/rural differences rather than typical western markers of socioeconomic status. However, within the urban populations, a higher prevalence of exercise-induced bronchospasm has been found among better-off children and adolescents [11, 12].

In contrast to studies of asthma or wheeze prevalence, studies of severe asthma and complications, such as hospitalizations and mortality, have consistently shown these manifestations of the disease to be more common among low income or socially deprived groups [3, 9, 13–15].

Cape Town, South Africa, provides a particularly suitable setting to examine the association between asthma, socioeconomic status and urbanization because of the wide range of socioeconomic circumstances characterizing its population and the high rate of migration to urban areas among part of the population. There have also been no previous studies of asthma prevalence in Cape Town using a representative sample of the whole population.

The objective of this study was to examine the relationship between socioeconomic status and the prevalence of asthma symptoms in school pupils from Cape Town, using data obtained in the Cape Town arm of the international study of asthma and allergy in childhood (ISAAC) [16].

Methods

This study used the standardized ISAAC written and video questionnaires [16] to interview 13- and 14-yr-old pupils attending state schools in Cape Town. In order to ensure a good spread by socioeconomic status, schools were randomly sampled within three strata, defined sociopolitically: integrated, predominantly Coloured and predominantly Black. Under apartheid, South Africans were classified into one of four sociopolitically-defined groups. Black (alternatively, African), Coloured (mixed ancestry), White and Asian. The first three of these groups predominate in Cape Town. Residential areas and schools were segregated accordingly, with residential areas other than city centres and White suburban areas known as "townships", particularly areas in which Black people resided. In this report, township, if unqualified, means Black township. In the early 1990s, formerly White state schools began to admit pupils of all groups, a process accelerated after the lifting of the racial legislation in 1994. These schools are referred to as "integrated".

The original Cape Town ISAAC study included 5,178 pupils, a response rate of 82.8% [16]. For the purposes of this study, the original questionnaires were needed to record the address of each child. The questionnaires of 231 pupils (229 from three Black schools) could not be found, leaving a sample of 4,947 pupils attending 30 different schools: 1,826 (36.9%) pupils attending 17 predominantly Black (township) schools, 1,947 (39.4%) pupils attending seven predominantly Coloured schools, and 1,174 (23.7%) pupils attending six integrated schools.

The pupils completed the written questionnaire in one of three languages: Afrikaans, English, or Xhosa. Of the sample used in this study, 1,935 children (39.1%) answered in Afrikaans, 1,826 (36.9%) in Xhosa, and 1,186 (24.0%) in English. Two written questions relevant to this study were "Have you ever had asthma?" (asthma-ever) and "Have you had wheezing or whistling in the chest in the last 12 months?"

After completing the written questionnaire, the pupils were shown a video questionnaire, which consisted of five scenes each depicting a symptom of asthma, described as follows: wheeze at rest, exercise wheeze, night wheeze, night cough and severe wheeze. Pupils were asked whether they had experienced these symptoms (or whether they had been woken at night): 1) "at any time in your life"; 2) "if yes, whether this had happened in the last year"; and 3) "if yes, whether this had happened one or more times a month".

The address of each pupil was geographically coded (geocoded) by matching the address to a Geographical Information Systems (GIS) street map of Cape Town. The process of geocoding enabled the enumerator area in which the pupil lived to be identified in order to assign a deprivation score to the child. Of the 4,947 pupils, 4,706 (95.1%) were able to be geocoded using their residential address. The remaining 241 included 62 pupils outside the study area and 179 for whom a correct address could not be assigned. Most addresses (71.1%) could be directly geocoded onto the GIS map. The remaining addresses were entered manually (predominantly those of children residing in informal sections of townships with unnamed streets), by adding a point on the GIS map in the zone in which the child lived. This was sufficient to locate the child to their enumerator area, as the enumerator areas in these townships covered a large area.

A locally developed Levels of Living index was used to assign a level of socioeconomic deprivation (SED) to each enumerator area in Cape Town. The index used a combination of five variables, derived from the 1991 National Census, to measure deprivation in each enumerator area: income (the proportion of household heads earning >R10,000 per annum (~$2,000); education (the proportion of adults with higher than eighth Grade education); unemployment (the proportion of adults who were unemployed but actively seeking work); welfare (the proportion of household heads who were single mothers with at least three children); and overcrowding (the proportion of households with >1.5 residents·habitable room^{-1}). The composite deprivation score was used to rank all of the enumerator areas in the Cape Metropolitan Area. The ranked distribution was then divided into 10 quantiles to produce 10 SED bands ranging from 1 (least SED) to 10 (greatest SED).

Each of the 4,706 pupils could thus be assigned to an SED band according to the enumerator area in which they lived. For each question, a prevalence (%) was calculated for each SED band. Inconsistent responses to stem and branch questions were removed from the analysis, resulting in each question having a slightly different sample size.

The relationship between symptom prevalence and SED band was plotted on a graph and a linear correlation line superimposed to illustrate the direction of any trend. To test formally for trend, the response to each question (yes/no) was modelled against SED and treated as an ordinal variable on a 1–10 (least-to-greatest) scale, using logistic regression. Although it cannot be assumed that the odds ratio (OR) is constant across adjacent SED bands with respect to any asthma symptom prevalence, the OR derived from the model is a valid if crude measure of overall trend.

Recent migration from remote rural areas to Cape Town is a feature mainly of Black township pupils in Cape Town, many having been born in the Transkei or Ciskei regions of the Eastern Cape and having come to Cape Town for schooling. The association between asthma symptoms and a marker or urbanization, number of years spent in Cape Town, was examined in pupils attending township schools.

In addition, attendance at integrated schools by pupils with a township address was used as a marker of socioeconomic mobility, and their asthma prevalence was compared with that of pupils with township addresses attending township schools, as well as with that of their classmates in integrated schools.

This study was approved by the Ethics and Research Committee of the Medical Faculty of the University of Cape Town. Consent was obtained from the Dept of Education and school principals and relevant teachers. Potential participants were given a letter to take home to their parents, which explained the study and gave parents the option of withdrawing their child, 1 week before the questionnaire completion.

Results

Written questionnaire

Of the 4,706 pupils, 13.3% reported that they had ever had asthma, while 16.0% of 4,682 pupils reported

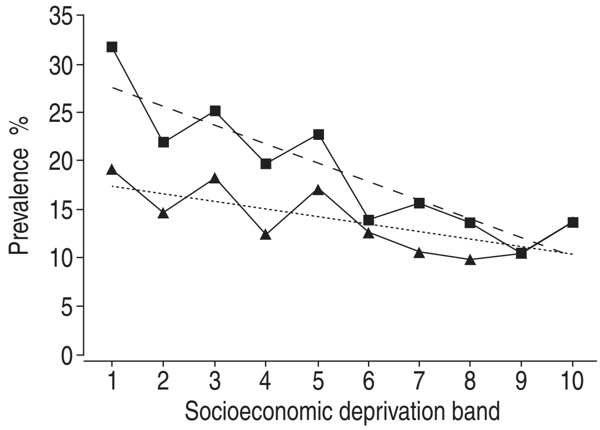

Fig. 1. – Prevalence of asthma-ever (··········) and recent wheeze (– – –) (written questionnaire) by socioeconomic deprivation in 4,706 Cape Town adolescents. ▲: pupils with asthma-ever; ■: pupils with recent wheeze.

experiencing wheeze in the last 12 months. Figure 1 demonstrates that the prevalence of asthma-ever and recent wheeze tended to fall with increasing SED, *i.e.* showing a negative association with SED. There was a slightly stronger negative association between SED and recent wheeze (OR 0.82, 95% CI 0.74–0.91) than between SED and asthma-ever (OR 0.88, 95% CI 0.80–0.97).

Video questionnaire

Table 1 summarizes the association between SED and each of the video questions. For nearly all of the video sequences, there was a negative relationship between SED and both the lifetime (ever) and recent (last 12 months) prevalence of asthma symptoms. By contrast, the prevalence of frequent symptoms (monthly or more) in the third question related to each video sequence tended to be positively related to SED. There was also a tendency for the OR to rise when moving from "at any time in your life" to "in the last year" to "one or more times per month". This was most apparent for wheeze at rest, night wheeze and night cough, and not apparent for exercise wheeze and severe wheeze.

Although most of the CIs in table 1 include one, it should be remembered that a single OR does not convey the true form of the association where the association varies across the strata forming the independent variable. In order to convey the specific form of the data and for the sake of brevity, the association between SED and asthma symptoms was described in more detail for three of the five video sequences, including wheezing at rest, night wheeze and severe wheeze (the pattern for exercise wheeze did not follow that of the other symptoms, while that of night cough was similar to that of night wheeze).

Wheeze at rest. In answer to the first question of the video sequence, 479 pupils (10.2% of all respondents) stated that they had experienced wheeze at rest at some time in their lives (table 2). Of these, 300 children (6.4% of all respondents) had experienced wheeze in the last year. Finally, 178 of these pupils (3.8% of all respondents) had suffered from wheeze one or more times per month in the last year.

The trends are demonstrated in table 1 and figure 2. The prevalence of wheeze at rest tended to be greater in the lower SED than the higher SED strata (OR 0.86, 95% CI 0.78–0.95), with band 2 being an outlier. The pattern of the data was similar for the association with wheeze in the last year (OR 0.88, 95% CI 0.77–1.00). By contrast, there was a positive, if somewhat variable, association between SED and "frequent" wheeze (OR 1.12, 95% CI 0.94–1.34).

Night wheeze. In total, 348 (7.4%) pupils responded that they had ever woken with night wheeze, and 181 (3.9%) of these had experienced night wheeze in the last year (table 2). One-hundred and twenty-six (2.7%) of these pupils had experienced night wheeze one or more times per month.

The trends are demonstrated in table 1 and figure 3. Again, there was a negative association (OR 0.83, 95% CI 74–0.94) between SED and the prevalence of night wheeze-ever, although the prevalence rose again in bands 9 and 10. There was a weak and more variable negative association with night wheeze in the last year (OR 0.92, 95% CI 0.77–1.10). Again, the association was reversed for "frequent" night wheeze, with a positive association between SED and night wheeze one or more times per month (OR 1.19, 95% CI 0.94–1.51).

Severe wheeze at rest. In the final video sequence, the pupils were asked whether they had experienced severe wheezing at rest with obvious breathlessness ("severe wheeze"). Four-hundred and fifty-five (9.7%) pupils stated that they had experienced severe wheeze at some point in their lives, of whom 241 (5.1%) had suffered such wheeze in the last year (table 2).

Table 1. – Association between asthma symptoms (video questionnaire) and socioeconomic deprivation in 4,706 adolescents in Cape Town

Asthma symptom	Ever	In the last year	One or more times per month
Wheeze at rest	0.86 (0.78–0.95)	0.88 (0.77–1.00)	1.12 (0.94–1.34)
Exercise wheeze	1.02 (0.94–1.10)	0.97 (0.87–1.09)	1.09 (0.95–1.25)
Night wheeze	0.83 (0.74–0.94)	0.92 (0.77–1.10)	1.19 (0.94–1.51)
Night cough	0.94 (0.87–1.02)	1.03 (0.92–1.15)	1.32 (1.14–1.52)
Severe wheeze	0.93 (0.84–1.03)	0.88 (0.76–1.03)	0.99 (0.81–1.19)

Data are presented as odds ratio with 95% confidence intervals in parentheses.

Table 2. – Prevalence of wheeze, night wheeze and severe wheeze (video questionnaire) by socioeconomic deprivation in Cape Town adolescents

Deprivation band	Ever	Recent	Frequent
Subjects n	4706#	4688#	4676#
Wheeze			
1 (246)¶	16.7	9.8	2.9
2 (247)	11.3	7.3	1.6
3 (225)	13.8	8.4	4.9
4 (251)	14.7	8.0	2.8
5 (193)	10.4	7.8	1.6
6 (261)	10.3	6.9	6.2
7 (338)	8.6	5.4	3.3
8 (399)	10.8	7.0	5.1
9 (855)	8.2	4.9	4.2
10 (1691)	9.1	5.8	3.8
Total	10.2	6.4	3.8
Night wheeze			
1	10.2	4.9	0.8
2	7.3	2.8	0.8
3	7.6	2.7	1.3
4	7.2	2.8	1.2
5	10.9	5.2	2.1
6	6.1	3.5	3.1
7	5.6	2.7	1.8
8	4.8	3.2	2.3
9	6.4	3.9	2.8
10	8.3	4.5	3.9
Total	7.4	3.9	2.7
Severe wheeze			
1	11.0	5.7	1.6
2	11.3	7.3	2.4
3	15.1	8.0	1.8
4	14.3	9.2	3.2
5	10.4	5.2	2.6
6	8.4	5.0	5.5
7	8.6	3.6	1.5
8	8.5	3.8	3.1
9	8.9	4.8	3.4
10	8.8	4.6	4.2
Total	9.7	5.1	3.4

Data are presented as %. #: Totals for wheeze (totals for other symptoms vary slightly); ¶: Stratum distribution for wheeze ever (other stratum distributions vary slightly).

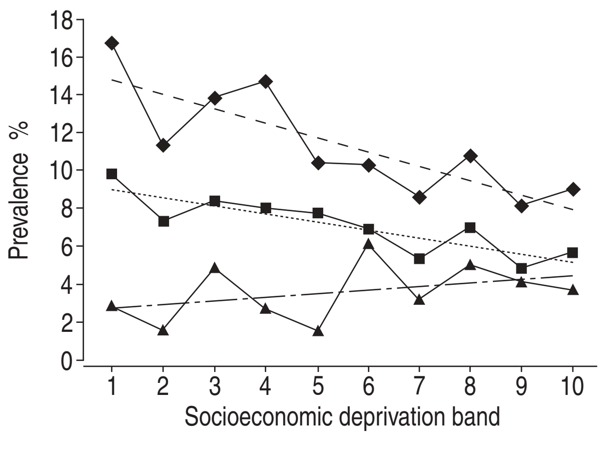

Fig. 2. – Prevalence of wheeze-ever (– – –) in the last year (·········) or one or more times per month (– - –) (video questionnaire) by socioeconomic deprivation in 4,706 Cape Town adolescents. ◆: pupils with wheeze-ever; ■: pupils with recent wheeze; ▲: pupils with frequent wheeze.

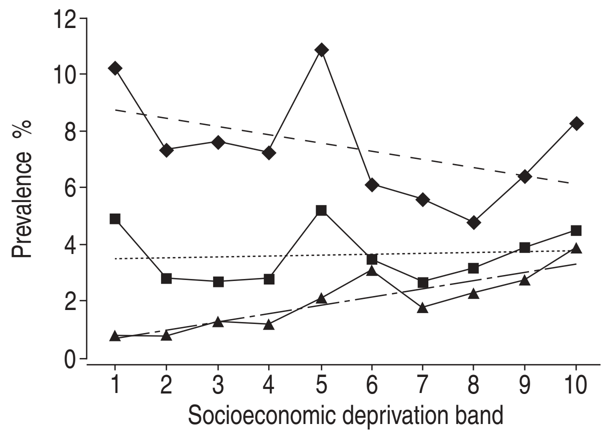

Fig. 3. – Prevalence of night wheeze-ever (– – –) in the last year (·········) or one or more times per month (– - –) (video questionnaire) by socioeconomic deprivation in 4,706 Cape Town adolescents. ◆: pupils with night wheeze-ever; ■: pupils with recent night wheeze; ▲: pupils with frequent night wheeze.

Of these, 157 pupils (3.4%) responded that they had suffered severe wheeze one or more times per month.

The relationships between SED and the three measures of severe wheeze are demonstrated in table 1 and figure 4. The pattern was similar to those described above: a negative association between SED and severe wheeze-ever (OR 0.93, 95% CI 0.84–1.03), and in the last year (OR 0.88, 95% CI 0.76–1.03). The figure shows a positive association between SED and severe one or more times per month, although no association is apparent in the overall OR (OR 0.99, 95% CI 0.8–11.19).

Urbanization and social mobility. Among the pupils attending Black township schools (n=1,811), no association was found between any of the asthma symptoms and the number of years spent living in Cape Town (data not shown).

However, there was a dramatic excess (fig. 5) in the

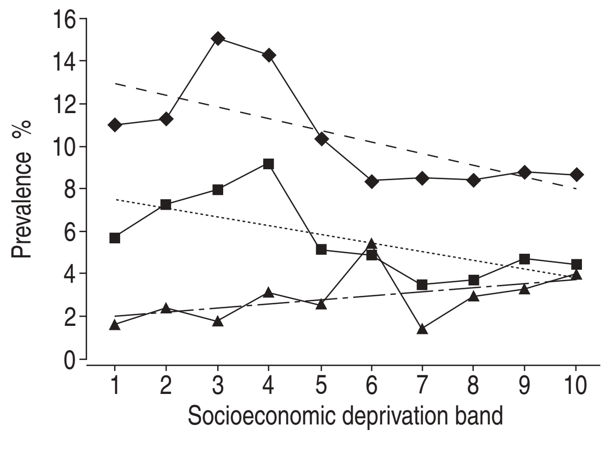

Fig. 4. – Prevalence of severe wheeze-ever (– – –) in the last year (·········) or one or more times per month (– - –) (video questionnaire) by socioeconomic deprivation in 4,706 Cape Town adolescents. ◆: pupils with severe wheeze-ever; ■: pupils with recent severe wheeze; ▲: pupils with frequent severe wheeze.

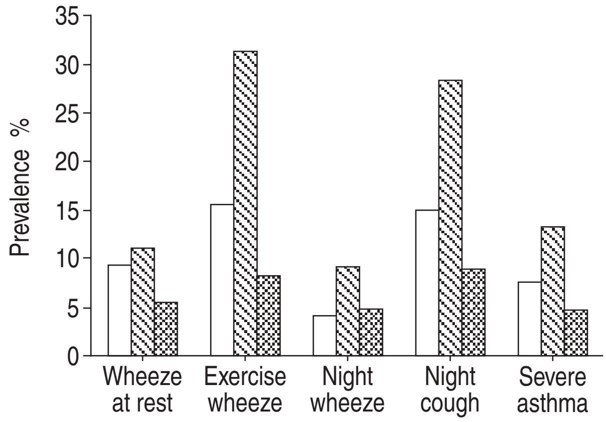

Fig. 5. – Prevalence of asthma symptoms in the last year in township and nontownship adolescents in Cape Town by school type. □: nontownship residents at integrated schools; ▧: township residents at integrated schools; ■: township residents at township schools.

prevalence of asthma symptoms reported by township pupils attending integrated schools (n=99) compared to that of township pupils attending township schools (n=1,712). The relative excess of symptoms among these commuting pupils was apparent even when all other pupils at integrated schools (n=1,075) were used for comparison.

Discussion

The findings of this study support the hypothesis that asthma occurs more frequently among adolescents of higher socioeconomic status in Cape Town. Using the written questionnaire, pupils living in better-off areas in Cape Town reported higher prevalences of asthma-ever (independently of a doctor's diagnosis) and recent wheeze than those living in the poorer areas.

The responses to the video questionnaire, however, pointed to a more complex relationship. For the majority of the video sequences, the higher the socioeconomic status, the greater the prevalence of asthma symptoms reported on the first two subquestions (referring to "at any time" in the respondent's life and "in the last year"). However, where the question concerned frequency of the symptom (monthly or more often) in the past year, the prevalence increased with greater social deprivation.

For example, of the 9.8% (n=24) of pupils in deprivation band 1 (least deprived) who reported wheeze in the last year, 29.2% (n=7) reported having this symptom one or more times per month. In contrast, while only 5.8% (n=98) of pupils in deprivation band 10 recorded wheezing in the last year, 64.3% (n=63) of these had it monthly or more often. For night wheeze, there was not much difference in 1-yr prevalence between deprivation band 1 (4.9%) and deprivation band 10 (4.5%). Among the better-off pupils, however, only 16.7% (n=2) of those with recent wheeze reported monthly symptoms compared to 86.7% (n=65) among the poorer pupils.

Reporting or diagnostic bias needs to be considered as an explanation for these findings. The diagnostic label "asthma" may be adopted earlier by better educated and more informed parents and children with superior access to medical care, accounting for its apparently higher prevalence (or equal prevalence where no gradient is apparent) among higher social classes. In contrast, poorer pupils may be less likely to report asthma or its symptoms because of reduced access to medical care, lower education levels and a setting in which respiratory symptoms such as cough may seem almost normal. Furthermore, symptoms occurring in the distant past may be discounted. With regard to severity, under-reporting of milder symptoms by poorer pupils would make it appear that severe asthma made up a greater proportion of their asthma occurrence.

An added dimension to reporting bias is the language differences that exist in Cape Town. There is no direct translation for words like "asthma" and "wheeze" in Xhosa, which may result in under-reporting of asthma symptoms among Xhosa-speaking pupils, who are over-represented in the higher deprivation groups. Use of the video questionnaire should have gone some way to overcoming diagnostic, education and language biases, although there may still be differences in the way pupils of different socioeconomic status acknowledge various symptoms or recognize video depictions.

What factors, other than under-reporting might underlie the higher prevalence of asthma among better-off adolescents in Cape Town? The spectrum of social deprivation includes not only traditional social-class variables, such as income, education and occupation (with a stratification rendered particularly sharp by apartheid), but also differences in urbanization, family size and diet.

In the current study, no effect of "urbanization" among black township pupils on asthma symptoms, as measured by years spent in Cape Town *versus* time in the rural hinterland, could be detected. However, lack of rural controls limited this analysis. A striking but unexpected finding was the high prevalence of all symptoms reported by pupils commuting from the Black townships to integrated schools, compared to pupils attending township schools. This suggests a powerful effect of factors associated with social mobility, as the higher costs of commuting, fees and extra expenditures associated with integrated state schools imply that these pupils come from the better-off families in their communities. Their symptom prevalences were higher even than their classmates from better-off residential areas, suggesting that the influences on asthma risk may be particularly high in the early or transitional cohorts of children undergoing social change. This finding, however, requires further investigation, including a possible change in the threshold for reporting symptoms.

Currently, there is interest in the characteristics associated with poorer living conditions that may exert a protective effect on the development of atopy and asthma, *via* the preferential stimulation of T-helper (Th)1 lymphocytes, with their inhibitory action on immunoglobulin-E synthesis and, therefore, atopy [17]. Infections in early life, associated with larger family size and poverty, may preferentially stimulate Th1 cell proliferation and subsequently inhibit allergen sensitization, thereby reducing the likelihood of asthma [18]. For example, it has been suggested that tuberculosis may be inversely related to the development of childhood atopic disease [19].

The protective effect of infection on asthma risk may be apparent in Cape Town, where levels of infectious disease are high in the poorer township areas. In 1996, the estimated incidence of tuberculosis in the Western Cape was the highest in South Africa, at 614 cases per 100,000 [20]. In South Africa, the prevalence of tuberculosis is a barometer of poverty. A study in Cape Town found that the prevalence of tuberculosis was inversely correlated with annual household income (correlation coefficient (r)=-0.60) and parental education (r=-0.64) [21]. As a result of the close association between race and socioeconomic status, the Black population in South Africa have a risk of tuberculosis 27-times greater than the White population [22]. The high levels of tuberculosis associated with poverty in Cape Town may thus be protective against asthma in the lowest socioeconomic groups.

The finding of greater disease severity among asthmatics in lower socioeconomic groups in Cape Town is supported by data from a parallel study, which found a strong positive association between social deprivation and admissions to intensive care units for asthma and (all-age) mortality from asthma [23]. Both environmental trigger factors and healthcare factors may be involved in this phenomenon. Frequent or more severe respiratory infections associated with crowded homes are likely to be important. Environmental tobacco smoke is a factor in many homes [24]. However, while rates of cigarette smoking among males in South Africa are higher in lower socioeconomic groups [25], the pattern among females is more complex. Generally, in the low-income population, Coloured females have very high smoking prevalence rates, including during pregnancy [24], while Black females have very low smoking rates [25]. Other contributory environmental factors in Cape Town, at least in winter, may be indoor pollution [26] and localized outdoor pollution from mixed fuel burning. There are no data on relative differences in indoor allergen exposures, such as to house dust mite, mould and cockroach.

Healthcare and disease management factors are likely to be equally important in the greater severity of asthma in poorer communities. Under-recognition and consequent undertreatment of asthma have been shown in some low income communities in this population, especially among those dependent on state medical care [27]. In South Africa, inequalities in access to medical care are a continuing legacy of apartheid, and closely follow racial and, therefore, socioeconomic lines. Although private medical care is available in poor areas, costs are a significant barrier for many. Many residents rely heavily on overburdened state primary healthcare services for the diagnosis and treatment of their asthma, and, until fairly recently, had little in the way of 24 h state services at primary level [28].

Lower income adolescents are also less likely to be on optimal asthma management regimens, including use of corticosteroids, and to rely on episodic care for acute exacerbations. The cost of maintenance treatment, particularly anti-inflammatory therapy, is a significant barrier, as in many poorer societies [29]. While low-income patients may obtain medication free of charge at state healthcare facilities in South Africa, there have been restrictions on strength and availability of anti-inflammatory therapy. Low educational levels are also associated with poor compliance and inappropriate usage of asthma medication. Resistance to the use of inhaled or continuous therapy in some low-income communities has been noted, with a preference for oral brochodilator medications, including theophylline [27, 28].

In conclusion, the findings of this study support an aetiological model in which factors associated with a higher standard of living increase the incidence of asthma, at least in a population with a wide and changing socioeconomic gradient such as Cape Town. Such factors may include less exposure to certain early childhood infections, such as tuberculosis. This increase in incidence may be particularly marked in subgroups undergoing rapid social mobility. Under-reporting of mild or remote symptoms by low-income respondents in questionnaire surveys may, however, contribute to this gradient. In turn, higher burdens of environmental trigger factors and poorer medical care are likely to be responsible for more severe asthma among those children or adolescents with asthma symptoms in low-income communities.

Acknowledgements. The authors would like to thank the Dept of Education of the Western Cape, the principals and teachers of participating schools and the parents for granting permission for the study. Thanks are also due to M. Mgijima, M. Bailey and R. Fischer for their assistance with the field study.

References

1. Peckham C, Butler N. A national study of asthma in childhood. *J Epidemiol Comm Health* 1978; 32: 79–85.
2. Kaplan BA, Mascie-Taylor CGN. Biosocial factors in the epidemiology of childhood asthma in a British national sample. *J Epidemiol Comm Health* 1985; 39: 152–156.
3. Goh DYT, Chew FT, Quek SC, Lee BW. Prevalence and severity of asthma, rhinitis, and eczema in Singapore schoolchildren. *Arch Dis Child* 1996; 74: 131–135.
4. Lai CKW, Douglass C, Ho S, Chan J, Wong G, Leung R. Asthma epidemiology in the Far East. *Clin Exp Allergy* 1996; 26: 5–12.
5. Persky VW, Slezak J, Contreras A, *et al.* Relationships of race and socioeconomic status with prevalence, severity, and symptoms of asthma in Chicago school children. *Ann Allergy Asthma Immunol* 1988; 81: 266–271.

6. Litonjua AA, Carey VJ, Weiss ST, Gold DR. Race, socioeconomic factors, and area of residence are associated with asthma prevalence. *Pediatr Pulmonol* 1999; 28: 394–401.
7. Peat JK, Woolcock AJ, Leeder SR, Blackburn RB. Asthma and bronchitis in Sydney schoolchildren. II: the effect of social factors and smoking on prevalence. *Am J Epidemiol* 1989; 111: 728–735.
8. Mitchell EA, Stewart AW, Pattemore PK, Asher MI, Harrison AC, Rea HH. Socio-economic status in childhood asthma. *Int J Epidemiol* 1989; 18: 888–890.
9. Strachan DP, Anderson HR, Limb ES, O′Neill A, Wells N. A national survey of asthma prevalence, severity, and treatment in Great Britain. *Arch Dis Child* 1994; 70: 174–178.
10. SIDRIA (Italian Studies on Respiratory Disorders in Childhood and the Environment). Asthma and respiratory symptoms in 6–7 yr old Italian children: gender, latitude, urbanization and socioeconomic factors. *Eur Respir J* 1997; 10: 1780–1786.
11. Keeley DJ, Neill P, Gallivan S. Comparison of the prevalence of reversible airways obstruction in rural and urban Zimbabwean children. *Thorax* 1991; 46: 549–553.
12. Addo Yobo EOD, Custovic A, Taggart SCO, Asafo-Agyei AP, Woodcock A. Exercise induced broncho-spasm in Ghana: differences in prevalence between urban and rural schoolchildren. *Thorax* 1997; 52: 161–165.
13. Mielck A, Reitmeir P, Wjst M. Severity of childhood asthma by socioeconomic status. *Int J Epidemiol* 1996; 25: 388–393.
14. Ehrlich RI, Bourne DE. Asthma deaths among coloured and white South Africans: 1962–1988. *Respir Med* 1994; 88: 195–202.
15. Claudio L, Tulton L, Doucette J, Landrigan PJ. Socioeconomic factors and asthma hospitalization rates in New York City. *J Asthma* 1999; 36: 343–350.
16. ISAAC Steering Committee. Worldwide variations in prevalence of symptoms of asthma, allergic rhino-conjunctivitis, and atopic eczema: ISAAC. *Lancet* 1998; 351: 1225–1232.
17. Hopkin JM. Mechanisms of enhanced prevalence of asthma and atopy in developed countries. *Curr Opin Immunol* 1997; 9: 788–792.
18. Martinez FD. Role of viral infections in the inception of asthma and allergies during childhood: could they be protective? *Thorax* 1994; 49: 1189–1191.
19. Shirakawa T, Enomoto T, Shimazu S-I, Hopkin J. The inverse association between tuberculin responses and atopic disorder. *Science* 1997; 275: 77–79.
20. Sidiropoulos E, Jeffrey A, Forgey H, *et al.* South Africa Survey 1997/1998. Johannesburg, South African Institute of Race Relations, 1998.
21. Van Rie A, Beyers N, Gie RP, Kunneke M, Zietsman L, Donald PR. Childhood tuberculosis in an urban population in South Africa: burden and risk factors. *Arch Dis Child* 1999; 80: 433–437.
22. Andersson N. Tuberculosis and social stratification in South Africa. *Inter J Health Services* 1990; 20: 141–165.
23. Poyser MA. Social deprivation and asthma prevalence, ICU admissions and mortality in Cape Town. University of Cape Town, Cape town, South Africa, M.Sc, 2000.
24. Ehrlich RI, Du Toit D, Jordaan E, *et al.* Risk factors for childhood asthma and wheezing: the importance of maternal and household smoking. *Am J Respir Crit Care Med* 1996; 154: 681–688.
25. Reddy P, Meyer-Weitz A, Yach D. Smoking status, knowledge of health effects and attitudes towards tobacco control in South Africa. *S Afr Med J* 1996; 88: 1389–1393.
26. Bailie RS, Pilotto LS, Ehrlich RI, Mbuli S, Truter R, Terblanche P. Paraffin and other fuels as sources of indoor air pollution in poor urban environments. *J Epidemiol Comm Health* 1999; 53: 585–586.
27. Ehrlich RI, Jordaan E, du Toit D, Volmink JA, Weinberg E, Zwarenstein M. Underrecognition and undertreatment of asthma in Cape Town primary school children. *S Afr Med J* 1998; 88: 986–994.
28. Jones SL, Weinberg M, Ehrlich RI, Roberts K. Knowledge, attitudes and practices of parents of asthmatic children in Cape Town. *J Asthma* 2000; 37: 519–528.
29. Watson JP, Lewis RA. Is asthma treatment affordable in developing countries? *Thorax* 1997; 53: 605–606.