ORIGINAL ARTICLE

Influence of family income on hospital visits for asthma among Canadian school children

R E Dales, B Choi, Y Chen, M Tang

Thorax 2002;**57**:513–517

See end of article for authors' affiliations

Correspondence to: Dr R E Dales, Ottawa Hospital, General Campus, 501 Smyth Road, Ottawa, Ontario, Canada K1H 8L6; rdales@ottawahospital.on.ca

Revised version received 13 December 2001
Accepted for publication 2 January 2002

Background: A study was undertaken to investigate the mechanisms by which socioeconomic status may influence asthma morbidity in Canada.
Methods: A total of 2968 schoolchildren aged 5–19 years with reported asthma were divided into three family income ranges. Hospital visits and risk factors for asthma, ascertained by questionnaire, were compared between the three groups.
Results: The mean (SE) annual period prevalence of a hospital visit was 25.0 (3.1)% among schoolchildren with household incomes of less than $20 000 Canadian compared with 16.0 (1.3)% among those with incomes of more than $60 000 ($p<0.05$). Students with asthma from lower income households were more likely to be younger and exposed to environmental tobacco smoke and cats, and their parents were more likely to have a lower educational attainment and be unmarried ($p<0.05$). Across all income groups, younger age, lower parental education, having unmarried parents, and regular exposure to environmental tobacco smoke were each associated with an increase in risk of a hospital visit ($p<0.05$). No increased risk was detected due to sex, having pets, and not taking dust control measures. Although not statistically significant at $p<0.05$, there may have been an interactive effect between income and susceptibility to environmental tobacco smoke. In the lower income group those children who were regularly exposed to second hand smoke had a 79% higher risk of a hospital visit compared with a 45% higher risk in the higher income group. In a logistic regression model the association between income and hospital visit was no longer significant after adjusting for differences in reported exposure to passive smoking.
Conclusion: Socially disadvantaged Canadian schoolchildren have increased asthma morbidity. Exposure to cigarette smoke appears to be one important explanation for this observation.

Lower income and socioeconomic deprivation have been associated with both increased asthma prevalence and morbidity,[1–5] but the explanation for this association is unclear. Socioeconomic status is believed to be a proxy for factors that directly affect health.[6] In the greater Boston area, higher cockroach and lower dust mite antigen levels were present in homes in higher poverty areas than in areas of lower poverty.[7] Environmental tobacco smoke exposure is greater among socioeconomically disadvantaged people,[6] and access to asthma care may also differ by social status. Areas of Philadelphia with a lower educational level had evidence of underutilisation of inhaled corticosteroids.[8] Lower income has been associated with a dependence on crisis orientated management for asthma.[2] Hospital admissions for asthma were more likely to come through an emergency department than from primary care physician referrals in poorer districts than in wealthier districts. [3]

A large questionnaire survey of schoolchildren with asthma throughout Canada (the Student Lung Health Survey) provided an opportunity to investigate further the mechanisms whereby lower income may increase asthma morbidity, as indicated by emergency department use or hospital admissions. Additional information and some preliminary findings of the Student Lung Health Survey can be found at http://www.hc-sc.gc.ca/hpb/lcdc/publicat/asthma/index.html.

This paper reports the results of the Student Lung Health Survey concerning the relationship between family income and asthma related outcomes. Several other risk factors for asthma such as increased exposure to asthma triggers, poor asthma control, underuse of asthma medication, and not possessing an action plan, which may have an impact on this relationship,[9–15] were also assessed.

METHODS

Study population

Students between the ages of 5 and 19 years inclusive were enrolled in the Student Lung Health Survey in 1995–6. They were selected from the following nine volunteer health units/departments across Canada that form the Sentinel Health Unit Surveillance System: Prince Edward Island; Halifax, Nova Scotia; Sherbrooke, Quebec; Kingston, Ontario; Guelph, Ontario; Winnipeg, Manitoba; Saskatoon, Saskatchewan; Edmonton, Alberta; and South Okanagan, British Columbia. The sentinel health units/departments represented approximately 10% of the Canadian population.

The sampling scheme was of a stratified multistage cluster design. Schools were categorised by level of education (elementary, secondary) and size (small, medium, large, very large). Within these strata a total of 136 schools were randomly selected. Students from small schools (less than 500 students) were 100% sampled while those from larger schools were randomly sampled by class or individually. Sampling was based on the total school population and number in each stratum obtained from the school enrolment lists of the school boards.

Data collection

The survey consisted of an initial screening questionnaire for all respondents and an asthma telephone survey for eligible respondents (students with asthma).

The screening questionnaire was used to define eligibility for the study and to define asthma. The diagnosis of asthma was operationally defined as a positive response to the question: "Have you ever been told by a doctor that you have

Table 1 Annual period prevalence of a hospital visit for asthma associated with demographic factors and environmental exposures and symptoms

	No.	%	OR (95% CI)
Age (years)			
5–12	1815	21.6	1.54 (1.24 to 1.91)**
13–19	1194	15.2	Reference
Unknown	1		
Sex			
Male	1571	18.9	1.01 (0.78 to 1.30)
Female	1439	18.8	Reference
Highest parental education			
Secondary school not completed	327	24.8	1.85 (1.21 to 2.82)**
Secondary school completed	1756	20.1	1.40 (1.05 to 1.88)*
University degree	885	15.2	Reference
Unknown	42		
Gross family income			
<$20 000	351	25.0	1.75 (1.19 to 2.59)**
$20 000–60 000	1517	19.4	1.27 (0.98 to 1.63)
>$60 000	771	16.0	Reference
Unknown	371		
Parental marital status			
Married	2414	18.6	Reference
Separated/divorced/widowed	430	18.0	0.96 (0.67 to 1.36)
Single, never married	124	30.5	1.92 (1.18 to 3.12)**
Unknown	42		
Cats			
Yes	903	17.7	0.90 (0.71 to 1.14)
No	2106	19.4	Reference
Unknown	1		
Dogs			
Yes	1075	14.6	0.64 (0.51 to 0.80)
No	1934	21.1	Reference
Unknown	1		
Regularly exposed to second hand smoke at home			
Yes	1047	23.4	1.55 (1.22 to 1.97)**
No	1947	16.4	Reference
Unknown	16		
Asthma symptoms experienced daily or almost daily			
Yes	323	35.4	2.32 (1.70 to 3.17)**
No	2150	19.1	Reference
Unknown	537		
Sleep disturbed due to asthma more than twice a month			
Yes	377	33.7	2.38 (1.77 to 3.21)**
No	2518	17.7	Reference
Unknown	115		

*p<0.05, **p<0.05

asthma?" Current asthma was based, in addition, on the presence of any one of the following three conditions in the previous 12 months: wheezing or whistling in the chest; an asthma attack; taking asthma medications. Current asthma was also considered to be present if a physician had diagnosed asthma and the subject was taking an anti-asthmatic medication for "a breathing problem" and it helped the symptoms.

Students with asthma were subsequently administered a more detailed asthma telephone survey, while those who did not fulfil the definition of asthma were not contacted further. For elementary students the screening questionnaire was distributed and collected by teachers. For secondary students it was mailed to their homes. Based on the response, students were categorised as: (1) ineligible (outside the ages of 5–19 years), (2) non-respondents (the questionnaire was not returned), (3) non-participants (permission was not given to further contact them or the returned questionnaire provided no information apart from personal identifiers), or (4) participants (the screening questionnaire was completed and permission given for the asthma telephone survey). The asthma telephone survey was conducted afterwards and a more detailed questionnaire administered to those participants who fulfilled the diagnosis of current asthma based on the screening questionnaire. For those aged less than 13 years, the parent/guardian completed the questionnaire.

Household income was defined by the response to the question: "What is your best estimate of the total income before taxes and deductions of all household members from all sources in the past 12 months?"

A hospital visit was defined as self-reporting of an emergency visit, or one or more nights in hospital due to asthma in the previous 12 months.

Statistical analysis

Because the study used a complex survey design which incorporated stratification, multiple stages of selection, and unequal probabilities of selection for study subjects, weighted statistical analysis was used. Sampling weights were calculated for each student based on the probability of the school being sampled, a function of response rates, and the proportion of schools selected in a given stratum. For each participant there was a sample weight associated with his or her data. All point estimates in this analysis were weighted to the target population using the sample weights.

A complex survey design also tends to increase the variance that would have been obtained through simple random sampling because of intracluster correlation. Design effect was used to summarise the effect of the complex survey design on variance estimates, which is the ratio of an estimated variance based on the survey to a comparable estimate of variance from a simple random sample of the population.[16] The Taylor approximation technique of the SUDAAN program[17] was used to take the design of the study into consideration. Based on the variance for each point estimate, the 95% confidence

Table 2 Distribution of demographic factors, environmental exposures, and asthma symptoms by household income

	<$20 000 (n=351)		$20 000– 60 000 (n=1517)		>$60 000 (n=771)	
	No.	%	No.	%	No.	%
Age (years)						
5–12	222	67.3	944	59.8	452	56.9**
13–19	129	32.7	572	40.2	319	43.1
Sex						
Male	160	45.3	815	53.5	414	53.2
Female	191	54.7	702	46.5	357	46.8
Highest parental education						
Secondary school not completed	140	38.8	139	8.3	8	0.6
Secondary school completed	190	55.5	1065	69.6	302	37.5
University degree	21	5.7	312	22.1	461	61.9**
Unknown	0		1	0.1	0	
Parental marital status						
Married	116	33.0	1278	83.8	744	96.9**
Separated/divorced/widowed	166	46.8	198	13.5	21	2.6
Single (never married)	68	20.0	40	2.6	6	0.5
Unknown	1	0.2	1	0.1	0	
Cats						
Yes	120	33.5	468	27.9	210	22.2*
No	231	66.5	1049	72.1	560	77.4
Unknown	0		0		1	0.3
Dogs						
Yes	83	22.3	557	35.1	313	37.33**
No	268	77.7	959	64.9	458	62.67
Unknown	0		1	0.03	0	
Regularly exposed to second hand smoke at home						
Yes	194	56.8	574	38.4	151	19.7**
No	157	43.3	936	60.9	614	79.4
Unknown	0		7	0.7	6	0.9
Asthma symptoms experienced continually (daily or almost daily)						
Yes	66	19.1	134	9.3	81	11.1*
No	238	65.6	1109	72.7	543	69.9
Unknown	47	15.3	274	18.0	147	19.0
Sleep disturbed due to asthma more than twice monthly						
Yes	55	16.2	182	13.3	95	13.4
No	287	80.3	128	79.9	642	77.8
Unknown	9	3.5	54	6.8	34	8.7

*p<0.05, **p<0.01.

interval (95% CI) and standard error (SE) were calculated. In hypothesis testing a p value of 0.05 (two sided) was used.

RESULTS

All of the selected schools participated in the survey. In the first stage a total of 39 794 students received the screening questionnaire; 373 were ineligible, 10 020 were non-respondents, 1371 were non-participants, and 28 030 were participants (students or their parents completed the screening questionnaire). The response rate for the first stage was 75% (1371 + 28 030)/(39 794 – 373). From the screening questionnaire, 3730 students who reported having current asthma were asked to participate in the second stage (more in-depth asthma telephone survey). Sixty four were found to be ineligible due to wrong age or class. Of the remaining 3666 eligible students, 398 could not be contacted despite multiple telephone contacts. Of the 3268 students contacted by telephone, 282 refused to participate leaving 2986 (91%) who participated in the study.

Table 1 shows the factors assessed for an association with asthma morbidity (hospital visits). Gross household income was inversely related to the annual period prevalence of a hospital visit in the past 12 months. The annual period prevalence of a hospital visit was 25.0 (standard error (SE) 3.1)% in schoolchildren with household incomes less than $20 000 Canadian dollars compared with 16.0 (SE 1.3)% in those with incomes of more than $60 000. The odds ratio (OR) was 1.75 which was statistically significant (p<0.05).

In addition, younger children (age 5–12 years, OR=1.54), lower parental education (some secondary or elementary school, OR=1.85), having unmarried parents (OR=1.92), and regular exposure to environmental tobacco smoke (OR=1.55) were each significantly associated with an increase in risk of a hospital visit. Symptoms of poor asthma control—for example, asthma symptoms experienced daily or almost daily, sleep disturbed due to asthma—were each associated with a 2–3-fold risk. Sex, having a cat at home, and dust control measures (such as covering mattress or pillows) were not associated with hospital visits, but having a dog at home was associated with a reduced number of visits to hospital.

Table 2 shows the differences in the distribution of asthma associated factors between household income groups. Several factors potentially associated with hospital visits were found to differ between income groups. Students with asthma from lower income households were more likely to be younger and their parents more likely to have a lower educational attainment and to be unmarried. They were more likely to be exposed to environmental tobacco smoke and cats. More importantly, the lower income group were more likely to have poorly controlled asthma, as evidenced by the daily frequency of symptoms and school absence.

Table 3 shows differences in effect sizes of asthma associated factors between income groups. There were potential interactions between income and risk factors on asthma morbidity. Lower income tended to have a stronger adverse effect on asthma morbidity in those who were younger, male, or exposed to environmental tobacco smoke (table 3). In the lower income group, younger children were 52% more likely than older children to make a hospital visit compared with 18% in the higher income group. Hospital visits were 23%

Table 3 Annual period prevalence (% with 95% CI) of a hospital visit for asthma in relation to demographic factors, environmental exposures, and asthma symptoms by household income

	<$20 000 (n=351)	$20 000–60 000 (n=1517)	>$60 000 (n=771)
Age (years)			
5–12	28.2 (20.9 to 35.5)	22.9 (19.4 to 26.4)	17.1 (14.0 to 20.2)
13–19	18.5 (9.5 to 27.5)	14.3 (10.4 to 18.2)	14.5 (10.4 to 18.6)
Sex			
Male	27.9 (18.9 to 36.9)	18.7 (15.4 to 22.0)	16.6 (12.3 to 20.9)
Female	22.7 (14.1 to 31.3)	20.3 (16.0 to 24.6)	15.3 (11.2 to 19.4)
Highest parental education			
Secondary school not completed	29.3 (20.3 to 38.3)	22.1 (14.3 to 29.9)	35.0 (0 to 70.3)
Secondary school completed	23.5 (15.9 to 31.1)	20.1 (17.6 to 22.6)	18.2 (13.3 to 23.1)
University degree	10.9 (0 to 25.6)	16.5 (10.6 to 22.4)	14.5 (11.4 to 17.6)
Parental marital status			
Married	24.2 (13.6 to 34.8)	19.5 (17.0 to 22.0)	16.5 (13.8 to 19.2)
Separated/divorced/widowed	20.6 (12.0 to 29.2)	18.1 (10.8 to 25.4)	–
Single (never married)	37.1 (23.6 to 50.6)	23.3 (10.4 to 36.2)	–
Cats			
Yes	20.9 (10.9 to 30.9)	16.8 (11.9 to 21.7)	19.6 (12.3 to 26.9)
No	27.1 (20.2 to 34.0)	20.4 (17.9 to 22.9)	15.0 (12.5 to 17.5)
Dogs			
Yes	16.5 (7.7 to 25.3)	14.9 (11.4 to 18.4)	12.5 (8.6 to 16.4)
No	27.5 (20.2 to 34.8)	21.9 (19.0 to 24.8)	18.1 (14.2 to 22.0)
Regularly exposed to second hand smoke at home			
Yes	30.9 (22.7 to 39.1)	23.1 (19.0 to 27.2)	21.0 (13.9 to 28.1)
No	17.3 (11.2 to 23.4)	17.1 (14.2 to 20.0)	14.5 (11.6 to 17.4)
Asthma symptoms experienced continually (daily or almost daily)			
Yes	38.1 (23.0 to 53.2)	36.3 (26.5 to 46.1)	28.1 (16.1 to 40.1)
No	24.8 (17.9 to 31.7)	19.8 (16.9 to 22.7)	16.5 (13.2 to 19.8)
Sleep disturbed due to asthma more than twice monthly			
Yes	30.5 (13.8 to 47.2)	37.7 (29.5 to 45.9)	23.8 (13.0 to 34.6)
No	24.6 (17.7 to 31.5)	17.8 (15.1 to 20.5)	15.8 (12.9 to 18.7)

higher in males than in females in the lower income group compared with 8% in the higher income group. In the lower income group, those children who were regularly exposed to second hand smoke had a 79% higher risk of hospital visits compared with a 45% higher risk in the higher income group. Other potential risk factors (parental marital status, asthma control, and medication intensity), however, did not appear to have a similar trend of interaction across income groups.

A multiple logistic regression model was used to assess the effect of income on emergency department visits or hospital admissions for asthma after other variables were taken into consideration. Low income was significantly related to a hospital visit for asthma after adjustment for age, sex, and medication intensity (short acting β agonist only, an inhaled corticosteroid plus any other medications except oral corticosteroids, and use of oral corticosteroids plus any other medications) (table 4). However, when either education or environmental tobacco smoke was included in the model, the relation between income and asthma was no longer significant.

DISCUSSION

Schoolchildren of lower income families have higher rates of hospital visits. Factors associated with an increased risk of hospital visits and with lower income included younger age, lower education, unmarried parents, and exposure to environmental tobacco smoke. The magnitude of the effects of younger age, male sex, and second hand smoke exposure tended to be greater among poorer families. Once the differences between income groups in environmental tobacco smoke exposure were controlled, the relation between income and asthma was no longer significant, suggesting that this may partly explain the influence of social status on asthma. Controlling for education also reduced the association between income and asthma, but this was probably due to "over adjustment" because of the known association between income and education. Education, like income, is an indicator of social status which, unlike cigarette smoke, does not directly affect asthma morbidity.

As with all cross sectional studies, this study is susceptible to a number of biases.[18 19] Unlike randomised trials, cross sectional studies cannot randomly allocate potential risk factors for asthma between those who visit and those who do not visit emergency departments. Parents concerned about their child's asthma may take steps to reduce exposure to pets and house dust, in which case a decreased level of risk factors may be found among those children who had a hospital visit—for example, there was a significantly lower prevalence of dogs

Table 4 Odds ratio (95% CI) for household income in relation to the annual period prevalence of a hospital visit for asthma

	Income (reference >$60 000)	
	<$20 000	$20 000–60 000
Crude	1.75 (1.19 to 2.59)	1.27 (0.98 to 1.63)
Age + sex	1.68 (1.15 to 2.46)	1.24 (0.97 to 1.59)
Age + sex + medication intensity	1.76 (1.15 to 2.68)	1.28 (0.99 to 1.66)
Age + sex + education	1.33 (0.86 to 2.06)	1.10 (0.82 to 1.47)
Age + sex + ETS	1.43 (0.97 to 2.12)	1.15 (0.88 to 1.51)

ETS=environmental tobacco smoke.

kept inside the home among children with a hospital visit compared with those without a hospital visit. Physicians are likely to increase medication intensity when asthma is more severe. These interventions would tend to reduce, and may even reverse, the observed associations with asthma from those expected. Despite this, an adverse effect of passive smoking was still observed. Perhaps the addictive potential of smoking makes it less likely that parents will reduce household smoking, even though their children suffer from asthma.

Apart from identifying factors which may help to explain the increase in asthma morbidity among lower income families, we also noticed potential interactive effects whereby age, sex, and passive smoking had a stronger adverse effect in lower income families than in higher income families, although the interactions were not statistically significant on a multiplicative scale, probably because of the small sample size. An explanation for these potential interactions requires further investigation.

The increased incidence of emergency visits and hospital admissions for asthma may be due to an increased prevalence or severity of asthma in lower income groups or to an increased use of emergency facilities. Analysis of the Canadian National Population Health Survey indicated that the prevalence of asthma is increased in poorer families.[20] In the present study the severity of asthma appeared to be greater in the lower income groups, indicated by the increased prevalence of continual asthma symptoms (table 2). These observations suggest that the increased hospital visits for asthma in lower income groups are due to an increase in prevalence and/or severity, and are not only the result of a different threshold for using emergency services.

Lower income may also be associated with poorer housing quality and increased crowding which may influence respiratory infection, allergic reactions, and thereby asthma control. Lower income is also associated with lower educational attainment (another measure of social status) which may influence asthma knowledge and control. These issues were not addressed in the present study but merit further investigation.

The results of this study suggest that Canadian schoolchildren from lower income families have more asthma exacerbations necessitating an emergency department visit or admission to hospital. The observed association between income and asthma may partly be the result of an increased prevalence of possible risk factors for asthma such as environmental tobacco smoke and also an increased effect of these factors in the presence of low income. Given these findings, interventions targeting environmental tobacco smoke exposure among low income groups have the potential of reducing the disparity in asthma morbidity across social class.

ACKNOWLEDGEMENTS

The authors thank Linda Zenzilet, Chief, Sentinal Health Unit; Jan Appleton, Okanagan Similkameen Health Region, Kelowna, British Columbia; Cathy Turnbull-Spence, Elaine Saritson, Capital Health Authority-Public Health Services, Edmonton, Alberta; Cathy Anderson, Saskatoon District Health-Public Health Services, Saskatoon, Saskatchewan; Darlene Girard, City of Winnipeg Community Services, Winnipeg, Manitoba; Helen Kelly, Wellington-Dufferin-Guelph Health Unit, Fergus, Ontario; Sara MacMartin, Kingston, Frontenac and Lennox and Addington Health Unit, Kingston, Ontario; Suzanne Ménard, Direction de la Santé Publique de l'Éstrie, Sherbrooke, Québec; Karen Urquhart, Public Health Services, Central Regional Health Board, Halifax, Nova Scotia; Arleen Latorraco-Walsh, Walena Doucette, Department of Health and Social Services, Charlottetown, Prince Edward Island; Jill Lava, Rachel Moore, Felix Li, Sawson El-Saadany, Linda Senzilet, Louise McRae, Peter Walsh, Charles Mustard, Robert Jin, Paula Stewart, Health Canada; Mukund Nargundkar, Georgia Roberts, David Lawrence, Jacqueline Pottle, Laurie Barnes, Statistics Canada; and The Canadian Population Health Initiative.

Authors' affiliations
R E Dales, Department of Medicine, University of Ottawa, and Clinical Epidemiology Program, Ottawa Health Research Institute, Ontario, Canada
B Choi, Surveillance and Risk Assessment Division, Centre for Chronic Disease Prevention and Control, Population and Public Health Branch, Health Canada, Ottawa, Ontario, Canada K1A 0K9
Y Chen, M Tang, Department of Epidemiology and Community Medicine, Faculty of Medicine, University of Ottawa, Ottawa, Ontario, Canada

REFERENCES

1 **Chen Y**, Dales R, Krewski D, *et al*. Increased effects of smoking and obesity on asthma among female Canadians: The National Population Health Survey, 1994–1995. *Am J Epidemiol* 1999;**150**:255–62.
2 **Hanania NA**, David-Wang K, Kesten S, *et al*. Factors associated with emergency department dependence of patients with asthma. *Chest* 1997;**111**:290–5.
3 **Watson JP**, Cowen JP, Lewis RA. The relationship between asthma admission rates, routes of admission, and socioeconomic deprivation. *Eur Respir J* 1996;**9**:2087–93.
4 **Miller JE**. The effects of race/ethnicity and income on early childhood asthma prevalence and health care use. *Am J Public Health* 2000;**90**:428–30.
5 **Salmond C**, Crampton P, Hales S, *et al*. Asthma prevalence and deprivation: a small area analysis. *J Epidemiol Community Health* 1999;**53**:476–80.
6 **Sexton K**, Gong H Jr, Bailar JC III, *et al*. Air pollution health risks: do class and race matter? *Toxicol Ind Health* 1993;**9**:843–77.
7 **Kitch BT**, Chew G, Burge HA, *et al*. Socioeconomic predictors of high allergen levels in homes in the greater Boston area. *Environ Health Perspect* 2000;**108**:301–7.
8 **Lang DM**, Sherman MS, Polansky M. Guidelines and realities of asthma management. The Philadelphia story. *Arch Intern Med* 1997;**157**:1193–200.
9 **Adams RJ**, Smith BJ, Ruffin RE. Factors associated with hospital admissions and repeat emergency department visits for adults with asthma. *Thorax* 2000;**55**:556–73.
10 **Singh AK**, Cydulka RK, Stahmer SA, *et al*. Sex differences among adults presenting to the emergency department with acute asthma. *Arch Intern Med* 1999;**159**:1237–43.
11 **Farber HJ**, Johnson C, Beckerman RC. Young inner-city children visiting the emergency room (ER) for asthma: risk factors and chronic care behaviors. *J Asthma* 1998;**35**:547–52.
12 **Gergen PJ**, Fowler JA, Maurer KR, *et al*. The burden of environmental tobacco smoke exposure on the respiratory health of children 2 months through 5 years of age in the United States: Third National Health and Nutrition Examination Suvey, 1988 to 1994. *Pediatrics* 1998;**101**:E8.
13 **Ray NF**, Thamer M, Fadillioglu B, *et al*. Race, income, urbanicity, and asthma hospitalization in California: a small area analysis. *Chest* 1998;**113**:1277–84.
14 **Legorreta AP**, Christian-Herman J, O'Connor RD, *et al*. Compliance with national asthma management guidelines and specialty care: a health maintenance organization experience. *Arch Intern Med* 1998;**158**:457–64.
15 **Lieu TA**, Queensberry CP Jr, Capra AM, *et al*. Outpatient management practices associated with reduced risk pediatric asthma hospitalization and emergency department visits. *Pediatrics* 1997;**100**:334–41.
16 **Henry GT**. Practical sampling. *Applied social research methods series*. Newbury Park: Sage Publications, 1990.
17 **Shah BV**, Barnwell BG, Bieler GS. *SUDAAN user's manual*. 7.0 ed. Research Triangle Park, NC: Research Triangle Institute, 1996.
18 **Choi BCK**, Noseworthy AL. Classification, direction and prevention of bias in epidemiological research. *J Occup Med* 1992;**34**:265–71.
19 **Choi BCK**, Pak AWP. Bias, overview. In: Armitage P, Colton T, eds. *Encyclopedia of biostatistics*. Chichester: John Wiley & Sons, 1998: 331–8.
20 **Chen Y**, Dales RE, Krewski D. The association between obesity and asthma in women. *Am J Epidemiol* 1999;**150**:255–62.