

Trends in prevalence of childhood and parental asthma in Merseyside, 1991–2006

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ABSTRACT

Background To determine changes in prevalence of parental and childhood asthma in Merseyside between 1991 and 2006.

Methods Four standardized cross-sectional respiratory surveys using a parent-completed questionnaire were completed in 1991 ($n = 1171$), 1993 ($n = 2368$) 1998 ($n = 1964$) and in 2006 ($n = 1074$) among primary school children attending the same schools in lower socio-economic areas of Merseyside. Main outcome measures were prevalence of doctor diagnosed asthma (DDA) and the symptom triad of cough, wheeze and breathlessness (C+W+B+).

Results Between 1991 and 1998 prevalence of DDA increased ($P < 0.001$), but in 2006 this decreased from 29.8 to 19.4% ($P < 0.001$). Prevalence of C+W+B+ increased from 7.8 to 8.0% by 1998, then decreased to 6.7% in 2006 ($P = 0.39$). Between 1998 and 2006, childhood hospital admissions for respiratory illness decreased from 11.3 to 9.7% ($P = 0.23$). During this period paternal asthma prevalence increased from 8.6 to 10.7% ($P = 0.001$) and maternal asthma from 11.2 to 13.4% ($P = 0.09$).

Conclusions An increase in the prevalence of DDA and asthmatic respiratory symptoms occurred in children prior to 1998, but this had decreased by 2006. Prevalence of parental asthma increased during the same period.

Keywords asthma, children, parental, trends

Introduction

There has been an increase in the prevalence of childhood asthma in developed and westernized countries during the 1990s with high prevalence reported for the UK,^{1–5} although more recently there has been evidence of a plateau or even declining prevalence trends of wheezing/asthma prevalence in certain western cities.^{6–8} Prevalence may vary over time and between studies due to changes in diagnostic labelling, clinical practice or varying study methodologies all of which can affect the interpretation of secular trends.⁹ The same survey instruments and asthma definitions should be used for sequential surveys in the same defined populations in order to reduce bias. In 1991, 1993 and 1998 in Merseyside cross-sectional school surveys were undertaken using the same methodology which showed an increasing asthma prevalence in children aged 5–11 years.^{9,10} The aim

of the present study was to determine the trends in prevalence of childhood and parental asthma in these same primary school populations surveyed again in 2006, using the same standardized questionnaire and methodology. Trends between 1991 and 2006 were analysed.

Methods

A respiratory health survey of 1964 children, in the age group 5–11 years, from 15 primary schools were carried out in 1998, using a parent-completed questionnaire.

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In 2006, the same survey was repeated to compare childhood respiratory morbidity with the previous 1998 survey. The methodologies of the survey and core questions were similar for both the 1998 and 2006 studies except for minor modifications of the questionnaire related to parental smoking practices. International Study of Asthma and Allergies in Childhood (ISAAC) core questions were included in both the surveys.^{11,12}

Permission was obtained from School authorities for distribution of a parent-completed questionnaire to children identified using the class registers. All parents of children attending the 15 primary schools used for both surveys were requested to participate. Re-visits were conducted to ensure the inclusion of absentees. The primary schools selected in 2006 were the same as those previously surveyed in 1991, 1993 and 1998. The results of the 1991, 1993 and 1998 surveys have been previously reported.^{9,10,13} In the present analysis, prevalence estimates for doctor diagnosed asthma (DDA) and the symptom triad of cough, wheeze and breathlessness (C+W+B+) from the 1991 and 1993 surveys are included in a comparative analysis of trend with the 1998 and 2006 surveys.

The child's asthmatic status was based on the question 'has your child ever been diagnosed by a doctor as having asthma or bronchial asthma?' The analysis compared results between this definition of DDA or asthma defined on the basis of the combined symptom triad of C+W+B+. The presence of wheeze was determined by the question 'has your child ever had an attack of wheezing? (by wheezing I mean noisy breathing and a whistling sound coming from the chest)?'. In 1998, the ISAAC question on wheeze was introduced (has your child ever had wheezing or whistling in the chest at any time in the past). The presence of cough and breathlessness were determined by the question 'has your child ever been un-expectedly breathless at rest or more breathless than expected after exercise (by breathless I mean out of breath or puffed)?' and 'has your child ever seemed to cough more (or get more coughs) than other children?' The previous surveys conducted in this area have shown that this symptom triad was a suitable surrogate for childhood asthma.¹⁰ Parental asthma status was determined by the question 'does the child's father or mother suffer from asthma?'

The Townsend Deprivation Index derived from post-codes using the Manchester Information and Association Services Software (MIMAS), was used to classify socio-economic status. The Index consists of four population variables which are measures of local unemployment, car ownership, overcrowding and home ownership.¹⁴ Values range from -6 to +12 with a value below zero indicating areas

of better socio-economic status. Values above zero indicate an area of lower socio-economic status.

A record of the birthweight was requested. A question was asked about preterm birth, 'Was the baby born prematurely?' Low birthweight was defined as birthweight <2500 g and intra-uterine growth restriction as a term birth and birthweight <2500 g. All children were measured for height and weight. Height was measured to the nearest millimetre using a millimetre scale (Child Growth Foundation, UK) and weight was measured to the nearest 100 g using electronic scales (Seca, UK). Obesity was defined as a child with body mass index (BMI) Z-score ≥ 1.64 SD and overweight as BMI Z-score ≥ 1.04 SD based on UK 1990 reference standard.¹⁵ Maternal smoking during pregnancy was defined as maternal smoking of one or more cigarettes per day during pregnancy.

Statistical analysis used χ^2 tests for comparison of proportions and for analysis of trends, student's *t*-test for comparison of means and analysis of variance for group comparisons and difference between years. Multiple logistic regression using a backward stepwise method was used to estimate adjusted odds ratios and their 95% confidence intervals. Variables included in the model were those with a *P*-value <0.2 in univariate analysis and those empirically associated with asthma. These were: household socio-economic status, child age (<7 years), overweight, male child, low birthweight, preterm birth and allergy. The SPSS (Statistical package for social sciences) statistical package (version 17) was used for analysis.

Permission to undertake both the 1998 and 2006 surveys were obtained from the Ethics Committee, Royal Liverpool Children's Hospital NHS Trust, Alder Hey.

Results

The questionnaire response rates in the 1998 and 2006 surveys were 78.1% (1964/2514) and 30.3% (1074/3540), respectively. The majority of questionnaires were completed by mothers (82 and 78%, respectively). Descriptive characteristics for the children in the two surveys are summarized in Table 1. Comparing the 1998 and 2006 surveys there were small but significant differences in the mean age, weight, height and birthweight. There were no substantial changes in the ethnic composition of children in these schools as the area they are located in have only a small minority of ethnic groups.

In 1998 children were on average slightly older (8.1 versus 7.1 years), and as a consequence taller and heavier ($P < 0.001$). Mean BMI increased from 17.16 (2.8) in

Table 1 Sample description for 1998 and 2006 surveys

Characteristic	1998	2006	P-value
Mean age ± SD (years)	8.1 ± 1.8 (1778)	7.1 ± 2.1 (983)	0.007
Mean weight for age Z-score ± SD	0.15 ± 1.0 (1083)	0.69 ± 1.2 (919)	<0.001
Mean height for age Z-score ± SD	0.09 ± 1.01 (1080)	0.56 ± 1.6 (931)	<0.001
Mean BMI (wt/ht ²) ^a	17.16 ± 2.8 (1221)	17.69 ± 3.9 (777)	0.323
Mean birthweight ± SD (kg)	3.34 ± 0.58 (1829)	3.21 ± 0.67 (819)	0.536
Male (%)	51.6 (1955)	47.4 (1074)	0.139
Obesity ^b (%)	9.8 (1602)	13.7 (776)	<0.001
Overweight ^c (%)	14.0 (1602)	26.9 (776)	<0.001
Maternal smoking during pregnancy (%)	34.8 (1874)	28.0 (958)	<0.001
Paternal smoking during pregnancy (%)	45.3 (1294)	37.9 (763)	0.001
Household smoking during pregnancy (%)	58.3 (1924)	44.4 (944)	<0.001
Low birthweight (<2500 g) (%)	6.8 (1829)	11.9 (816)	<0.001
Preterm birth	12.4 (1879)	15.2 (933)	0.039
IUGR	1.8 (1834)	4.6 (834)	<0.001
Townsend score upper quartile ^d (+4 to +12)	92.0 (1806)	90.8 (657)	0.691

Brackets, sample size.
^aBody mass index (weight/height²).
^bBMI Z-score > 1.64 (95th percentile).
^cBMI Z-score > 1.04 (85th percentile).
^dLower socio-economic status.

1998 to 17.69 (3.9) in 2006 ($P = 0.323$). Between 1998 and 2006, there was also a significant increase in the prevalence of obesity (+3.9%) and overweight (+12.9%) (both $P < 0.001$). There was an increase in prevalence of low birthweight (+5.1%) ($P < 0.001$), preterm birth (+2.8%) ($P = 0.039$) and intra-uterine growth restriction (IUGR) (+2.8%) ($P < 0.001$). There was a decrease in prevalence of smoking among mothers (−6.8%), fathers (−7.4%) and household members (−13.9%) (all $P \leq 0.001$) during the mother's previous pregnancy comparing the 1998 and 2006 surveys.

Prevalence estimates for childhood respiratory symptoms, DDA and parental asthma for both surveys are summarized in Table 2. The largest negative change in prevalence occurred for well controlled asthma (−15.3%) ($P < 0.001$), with significant changes in DDA (−10.4%), wheezing

Table 2 Prevalence of respiratory characteristics for 1998 and 2006 surveys

Characteristic	1998	2006	P-value
Doctor diagnosed asthma	29.8 (565/1893)	19.4 (184/949)	<0.001
Wheezing	29.4 (535/1798)	20.6 (197/956)	<0.001
Excess cough	5.9 (105/1780)	16.4 (170/1037)	<0.001
Breathlessness	19.8 (182/921)	17.3 (162/936)	0.174
C+W+B+	8.0 (60/754)	6.7 (53/791)	0.394
Asthma well controlled ^a	85.6 (467/546)	70.3 (156/222)	<0.001
Hospital admission ^b	11.3 (213/1885)	9.7 (84/866)	0.234
School absenteeism ^c	39.9 (711/1782)	47.3 (74/157)	0.092
Allergies ^d	24.9 (435/1747)	16.1 (173/1081)	<0.001
Maternal asthma	11.2 (201/1797)	13.4 (125/934)	0.093
Paternal asthma	8.6 (141/1641)	10.7 (88/825)	0.001
Ratio F:M asthma	0.8:1.0	0.9:1.0	—

Brackets, sample size.
^aProportion of those with asthma in whom it was well controlled.
^bHas your child been admitted to hospital due to respiratory illness during the past 12 months?
^cAbsent for one or more days from school due to respiratory symptoms.
^dDoes your child have any allergies? (including allergic rhinitis).

(−8.8%) and allergy (−8.8%) (all $P < 0.001$). Prevalence of excess cough (+10.5%) ($P < 0.001$) increased. There was decrease in the prevalence of excess breathlessness, the symptom triad of C+W+B+ and hospital admission for respiratory symptoms, but these differences were not significant. School absenteeism for respiratory symptoms and maternal asthma prevalence both increased but this change was not significant.

Sex differences for prevalence of DDA and C+W+B+ are summarized in Table 3. Estimates were lower in 2006 than 1998 for both respiratory categories and the proportional change between the survey periods was comparable for both sexes. The negative percentage change between surveys in DDA was greater for males ($P < 0.001$). Conversely the negative percentage change for C+W+B+ was greater for females ($P < 0.001$).

Table 4 shows the logistic regression and adjusted odds ratios for DDA for the 1998 and 2006 surveys. Childhood asthma correlated with allergy in both surveys ($P < 0.001$), with preterm (1998, $P = 0.03$; 2006, $P = 0.05$), child age <7 years (1998, $P = 0.027$) and obesity in 2006 ($P < 0.019$). Table 5 summarizes logistic regression and adjusted odds ratios for childhood asthma defined by the symptom triad of C+W+B+. For the 1998 survey there were significant associations with allergy ($P < 0.001$), overweight ($P = 0.023$) and child age (<7 years) ($P = 0.041$).

Table 3 Sex differences in prevalence for doctor diagnosed asthma and C+W+B+

Sex	1998		2006		Percentage change	
	DDA	C+W+B+	DDA	C+W+B+	DDA	C+W+B+
M	32.6 (315/966)	8.3 (34/410)	20.9 (96/460)	7.5 (28/374)	-11.7*	-0.8*
F	27.0 (248/919)	7.6 (26/342)	18.0 (88/489)	6.0 (25/420)	-9.0*	-1.6*
M:F ratio	1:0.8	1:0.9	1:0.9	1:0.8	—	—

Brackets, sample size; M, male; F, female.

* $P < 0.001$ for difference between male and female.

Table 4 Odds ratio for childhood doctor diagnosed asthma^a

Factor	Survey year	Unadjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Allergy	1998	2.5	2.1–2.9	<0.001	3.6	2.8–4.9	<0.001
	2006	2.2	1.7–2.9	<0.001	3.8	2.1–6.4	<0.001
Preterm	1998	1.4	1.1–1.8	0.007	1.6	1.0–2.5	0.037
	2006	1.3	0.9–1.9	0.125	1.9	0.9–3.7	0.053
Child age(<7 years)	1998	1.1	1.0–1.2	0.015	1.5	1.0–2.2	0.027
	2006	1.0	0.9–1.2	0.125	0.8	0.5–1.4	0.830
Overweight	1998	1.5	1.2–1.8	0.001	1.4	1.0–2.0	0.069
	2006	1.1	0.8–1.5	0.363	0.7	0.3–1.4	0.269
Male child	1998	1.1	1.0–1.2	0.009	1.2	0.9–1.6	0.245
	2006	1.1	0.9–1.3	0.286	1.1	0.7–1.9	0.644
Lower socio-economic status	1998	0.9	0.9–1.0	0.496	1.2	0.6–2.3	0.524
	2006	1.0	0.8–1.1	0.449	1.2	0.5–2.7	0.755
MSDP	1998	1.0	0.9–1.2	0.829	1.1	0.8–1.5	0.675
	2006	1.1	0.8–1.4	0.355	1.6	0.9–2.9	0.084
Obesity	1998	1.7	1.2–2.3	0.003	1.1	0.6–2.1	0.788
	2006	1.6	1.1–2.3	0.025	2.1	1.1–4.1	0.019
Low birthweight	1998	1.2	0.8–1.7	0.417	0.9	0.5–1.9	0.810
	2006	1.0	0.6–1.7	0.889	0.6	0.2–1.7	0.360

^aVariables included in the model: household socio-economic status (upper quartile), child's age <7 years, obesity, overweight, male child, low birthweight, preterm birth and allergy.

MSDP, maternal smoking during pregnancy.

Questionnaire response rates in 1991 and 1993 were 92% (1171/1260) and 87% (2368/3275), respectively. Prevalence estimates in 1991 for DDA and C+W+B+ were 17.7 and 7.8% and the corresponding estimates for 1993 were 22 and 7.9%. Figure 1 illustrates prevalence estimates for the same variables for all four surveys. There was an increase in prevalence of DDA between 1991 and 1998 (χ^2 trend $P < 0.001$). There was no significant change between 1991 and 1998 for C+W+B+. The prevalence of DDA was lower in 2006 than for all previous surveys. A similar pattern was seen for excess breathlessness and wheezing as single

symptom categories. The prevalence of the symptom triad C+W+B+ showed less variation, but the lowest prevalence was in 2006.

Figure 2 compares the prevalence of DDA with prevalence estimates for parental asthma for the same years. Parental asthma prevalence sequentially increased between 1991 and 2006. This pattern was observed for mothers and fathers (mothers, χ^2 trend $P = 0.093$; fathers, χ^2 trend $P = 0.001$). Parental asthma showed no decline in prevalence in 2006, in contrast to the pattern in children.

Table 5 Odds ratio for childhood C+W+B+^a

Factor	Survey year	Unadjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Allergy	1998	4.5	2.4–8.4	<0.001	4.8	2.8–8.9	<0.001
	2006	12.6	2.9–26.7	<0.001	1.0	0.9–2.9	0.993
Overweight	1998	1.8	1.2–2.8	0.018	2.7	1.2–6.4	0.023
	2006	1.0	0.4–2.9	0.972	2.0	0.7–5.8	0.199
Child <7 years	1998	1.3	1.1–1.4	0.019	3.7	1.1–12.8	0.041
	2006	5.2	1.8–13.0	<0.001	2.4	0.9–6.3	0.074
Male child	1998	1.1	0.8–1.4	0.579	2.0	0.6–6.3	0.235
	2006	1.0	0.4–2.6	0.947	0.9	0.3–2.5	0.769
Preterm	1998	1.7	0.9–3.4	0.155	2.0	0.7–6.4	0.240
	2006	1.1	0.3–4.0	0.850	0.5	0.1–2.2	0.330
Lower socio-economic status	1998	0.9	0.8–1.0	<0.001	0.3	0.02–3.5	0.346
	2006	1.0	0.2–5.4	1.000	0.8	0.2–3.6	0.798
Low birthweight	1998	0.6	0.1–2.5	0.754	0.4	0.04–3.9	0.408
	2006	1.3	0.2–12.3	0.761	2.3	1.0–6.3	0.234
Obesity	1998	2.7	1.3–5.4	0.015	1.8	0.4–8.4	0.424
	2006	1.7	0.5–5.9	0.340	0.5	0.1–2.4	0.352
MSDP	1998	0.6	0.7–1.6	0.644	0.7	0.8–2.2	0.694
	2006	0.7	0.3–2.1	0.571	0.8	0.3–2.2	0.647

^aVariables included in the model: household socio-economic status (upper quartile), child’s age <7 years, obesity, overweight, male child, low birthweight, preterm birth and allergy.
MSDP, maternal smoking during pregnancy.

Discussion

Main findings of study

This analysis showed a significant decrease in prevalence of parentally reported DDA, wheezing and allergy between 1998 and 2006 among Merseyside primary school children. This was in contrast to parental asthma prevalence which increased in the same period. The decrease in childhood prevalence coincided with improved environmental control measures in the area, where the schools are mostly situated and where dock-related activities previously had resulted in substantial air pollution.¹³ The proportion reporting well controlled asthma declined between 1998 and 2006 suggesting these changes in prevalence were not necessarily related to improved management practices.

The difference in C+W+B+ prevalence between 1998 and 2006 was not significant although the directional change was the same as for DDA and this probably indicates a true reduction in asthma cases in children. There was a 32.8% reduction in DDA between the two surveys, but only 16.2% reduction in C+W+B+, which may mean that approximately half of the reduction in DDA was unrelated to the triad of C+W+B+ and may reflect changing physician diagnostic criteria. Alternatively, or in addition, there could have been a greater reduction of milder asthma cases

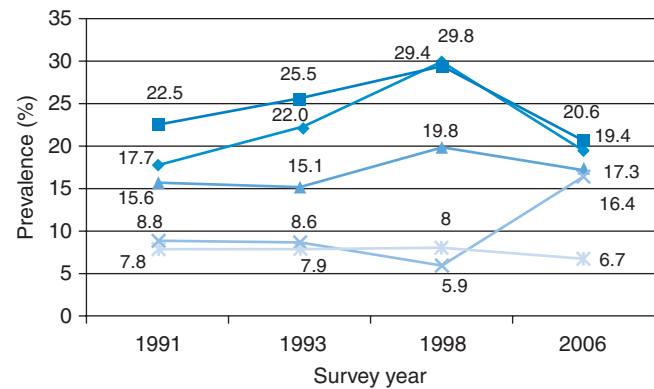


Fig. 1 Trends in prevalence of childhood respiratory profiles between 1991 and 2006. Closed diamonds, DDA; closed squares, wheezing; closed triangles, breathless; multi, cough; asterisks, C+W+B+. Numbers indicate symptom prevalence.

which may be labelled DDA by physicians, compared with those with more severe asthma. The decrease in DDA was associated with a decrease in allergy between 1998 and 2006. There were more mothers with asthma than fathers, which is the reverse of the male: female difference in childhood asthma which has higher prevalence in boys.

It is quite unlikely that methodological differences between the surveys would explain these findings as the

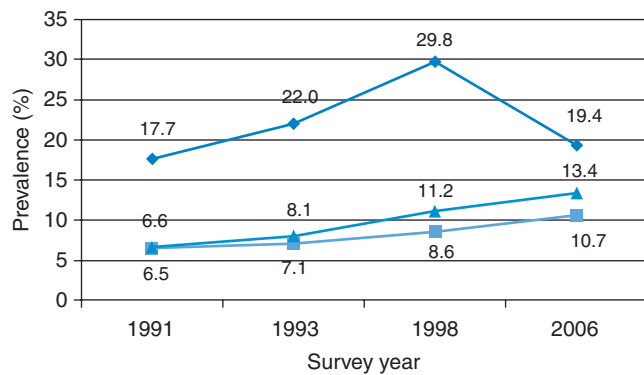


Fig. 2 Trends in prevalence of maternal and parental asthma between 1991 and 2006 compared with childhood asthma. Closed diamonds, DDA; closed squares, paternal asthma; closed triangles, maternal asthma. Numbers indicate asthma prevalence.

same survey methodology and schools were used for the cross-sectional surveys. The lower parental response rates with questionnaire completion in 2006 (30.3%) than in the 1998 survey (78%) could lead to bias. This reduction in questionnaire response rates is a recurrent problem in many school-based community surveys at the present time and in part relates to questionnaire overload and increasing auditing of school-related activities. Efforts were made to secure questionnaire response rates with re-visits for absenteeism and parental reminders. The smaller available study sample in 2006 may represent a sub-group which is less representative of the school population. Children with parents who are more aware of asthma illness and preventive factors may be over-represented due to response bias leading to over-estimation of asthma prevalence. In view of this, the observed reduction in prevalence is even more striking. The Townsend Deprivation scores were similar in the 1998 and 2006 study samples indicating these were comparable in terms of socio-economic status.

Confirmation of asthma diagnosis, birthweight or preterm status was not available from medical records. Over-reporting of symptoms may occur, or inaccurate recall of birthweight, although maternal recall of birthweight is considered reliable in the UK setting.¹⁶ The lower mean birthweight in 2006 was associated with increased low birthweight prevalence which corresponded with a significant increase in preterm birth and intra-uterine growth restriction. These differences in birth outcomes could indicate that the 2006 sample represented a sub-sample with different health characteristics. However, the poorer birth outcomes reported in the 2006 survey might be expected to lead to increased and not reduced asthma risk, as preterm birth was significantly related to DDA in the regression analysis (Table 4).¹⁷

What is already known on the topic

The decrease in the prevalence of DDA is consistent with other studies^{18–21} and may relate to altered patterns of respiratory infection reported in children with reduced environmental exposures,^{22–25} or secondary to improved immunization uptake and changing socio-economic circumstances.²⁶ The 1998 data set were from a deprived area with 92% of participants living in an area with a Townsend score between 4 and 12.

An absence of a sex difference in adult asthma has been reported,²⁷ although in a cohort study of asthmatic children followed from age 7 years, women were more likely to have adult asthma than men, as observed in the 1998 and 2006 surveys.²⁸ The higher prevalence in 2006 for parental asthma occurred in men and women with only a small change in the M:F ratio from the previous survey. An increasing prevalence of asthma in adults would be expected as cohorts of children experiencing a higher prevalence of asthma symptoms during the 1990s reached adult age without an age-related reduction of their asthma symptoms.⁹ A 2-fold rise in adult asthma prevalence in the last 20 years has also been reported from Scotland (2.8% in 1972–1976 to 8.0% in 1996).²⁹

In addition to this potential cohort effect, changes in dietary practices related to increased dietary intakes of poly-unsaturated fats or reduced intakes of antioxidant nutrients could contribute to increased asthma risk.^{30–32} Changing patterns in many potential factors may be implicated including air pollution, cigarette smoke exposure, household pets ownership and obesity. Between 1998 and 2006 there was reduction in parental smoking prevalence in pregnancy,³³ but not in pet ownership.³⁴

The higher prevalence of childhood obesity in the 2006 compared with 1998 reflected the national pattern in the UK of rising prevalence of childhood obesity.³⁵ DDA and C+W+B+ showed significant associations with obesity and overweight in the regression analysis (Tables 4 and 5). The lower asthma prevalence in 2006 is the reverse of what might be predicted against a background of increasing obesity prevalence in the same population group. Repeat surveys are required to monitor future trends in order to identify whether asthma prevalence continues to fall in relation to changing obesity prevalence or whether present levels are maintained.

What this study adds

There was an impressive reduction in childhood asthma prevalence between 1998 and 2006 following the sequential rise since 1991, and a significant reduction in the number of

childhood admissions for respiratory illness (11.3–9.7%) between these two survey periods. Whether this resulted from a primary reduction in asthma cases or was a result of improved management practices with better recovery from illness, or both, is uncertain.³⁶ The decrease in childhood admissions for respiratory illness is consistent with the decreased prevalence of DDA and of the symptom triad of C+W+B+ which could indicate a decrease in the number of severe cases. The proportion of children reported with well controlled asthma decreased. This may reflect changing perceptions in parental understanding of well controlled asthma, or that improved control was not achieved in a residual core group of cases.

Limitations

Reduced prevalence of childhood asthma could relate to improved patient awareness and better asthma management with increased attention to preventive measures. These were not assessed as part of this survey and we were unable to directly relate behavioural changes with respiratory profiles. Parental age was not requested and changes in behavioural patterns between adolescents and adults might relate to differences in asthma-related risk factors which could influence prevalence in older individuals.

Authors' contribution

G.K. and A.D. conducted the 2006 survey. B.B. designed the study and B.B., G.K. and A.D. participated in the analysis and interpretation of the results. B.B. and G.K. wrote the paper.

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