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Epidemiological measures of childhood asthma: Cross-sectional and longitudinal consistency

Cristina Canova [a,b,*], Jessica M. Harris [b,c], Pamela Mills [b], Carol White [b], Susan Moffat [b], Lesley Shread [b], Paul Cullinan [b]

[a] MRC-HPA Centre for Environment and Health, Respiratory Epidemiology and Public Health Group, National Heart and Lung Institute, Emmanuel Kaye Building, Manresa Road, Imperial College, London SW3 6LR, UK
[b] Department of Occupational and Environmental Medicine, National Heart and Lung Institute, Imperial College London, London, UK
[c] School of Clinical Science, University of Bristol, Bristol, UK

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Summary
Background: Defining childhood asthma varies considerably, and the extent of agreement between various measures is not clearly understood in the absence of a recognized 'gold standard'. We compared different definitions of childhood asthma, identified characteristics that might have influenced their accuracy and an acquisition of an 'asthma' label in wheezy and treated children.
Methods: Using a prospective, population-based birth cohort of 623 children followed up to the age of 14 years the concordance between parental opinion, doctor's diagnosis reported by the parent and asthma's diagnosis in general practice (GP) was analysed using latent class analysis (LCA).
Results: At the age of eight, 'ever asthma' prevalences ranged from 15.5% (parental opinion) to 21.5% (GP record). 35% of children *by* the age of eight years had at least one reported label of asthma, reflecting both cross sectional and longitudinal inconsistencies. By the age of 14 years, 16% of children were inconsistently defined as 'ever asthmatic' by their parents. The prevalence of 'ever asthma' estimated by LCA was 19.3%, indicating a parental report of a doctor's diagnosis to be the most sensitive and specific definition. The likelihood of being labelled with asthma was higher in those with a parental or sibling history of asthma, but not determined by socio-demographic characteristics.

* Corresponding author. MRC-HPA Centre for Environment and Health, Respiratory Epidemiology and Public Health Group, National Heart and Lung Institute, Emmanuel Kaye Building, Manresa Road, Imperial College, London SW3 6LR, UK. Tel.: +44 0 207 352 8121x3520; fax: +44 0 207 351 8322.
E-mail address: c.canova@imperial.ac.uk (C. Canova).

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Conclusions: Although the estimates of prevalence were similar for parental reports and GP records, agreement between the three sources was less than expected. Parental report of a doctor's diagnosis of asthma is sensitive, specific, longitudinally consistent and not subject to large socio-economic bias.

Introduction

In the absence of a recognized 'gold standard' both the diagnosis and measurement of childhood asthma remain challenging for clinicians and epidemiologists.[1,2] In population-based research and in disease surveillance, methods of ascertaining and defining asthma vary considerably, and the extent of agreement between various measures is not clearly understood.[3] In a recent systematic review of 122 epidemiological papers, over 60 definitions of childhood asthma were used, the most common being the parental report of a doctor's diagnosis of the disease, either alone or in combination with characteristic symptoms or specific medications[4]; 78% of papers in the review used solely information from questionnaires or interviews with parents, while just 7% included more objective information from clinical measurements. There is reasonable evidence that in both children and adults, symptoms questionnaires are a valid measure of asthma prevalence in comparison to physiological indices such as bronchial reactivity.[1,2,5,6] Other measures, including the use of asthma medications or of primary care or hospital services, can be difficult to interpret, especially in geographical comparisons where they are sensitive to health care factors.

Asthma tends to be a remitting disease and its prevalence is not usually measured by the presence of symptoms at the time of survey (point prevalence) but either by the report of symptoms over a defined prior period, commonly one year (period prevalence), or by the response to an 'ever' question (life-time prevalence). In young children, the prevalence of 'ever' asthma amounts to a measure of lifetime incidence but as age increases, there is increasing inaccuracy and bias due to recall and severity.[7] At any age, the choice of a measurement of asthma depends on the design and aim of the study: estimates of prevalence require a method with high sensitivity, whereas studies that aim to examine the aetiological determinants or natural history of the disease are better served by measurements with a high specificity. The choice will, further, be determined by matters of feasibility, cost and acceptability.

Estimates of asthma prevalence based separately on parental report and medical record have been compared — and the sources of any disagreement explored — in a very small number of cross-sectional surveys [8–10]; but no studies, to our knowledge, have compared several sources of parental report or assessed their cross-sectional and longitudinal consistency. Furthermore, very few studies have examined why among children with similar symptoms, some are labelled as having asthma while others are not.[11–13]

We aimed, within a 14-year, prospective, population-based birth cohort, to describe the prevalence of variously labelled asthma; to detect possible inconsistencies in both cross-sectional and longitudinal disease definitions; to identify factors that might determine the accuracy of reported asthma; and to identify characteristics that influence the acquisition of an 'asthma' label in wheezy and treated children.

Methods

Population and collection of data

The formation of the cohort is described in more detail elsewhere.[14,15] Briefly, between November 1993 and September 1995, all newly-pregnant women presenting for ante-natal care at three general practices (GP) in Ashford (Kent, UK) were invited to take part in a longitudinal study of asthma. A total of 710 women were approached, 658 (92.7%) agreed to participate and 642 babies were born. The children were visited at home (later at school) annually until age 5½ and at ages eight ($n = 593$, 92%) and 14 (499, 78%) years. On each occasion, a parent of the child was interviewed to collect detailed information on respiratory symptoms over the past year.

At ages three, six and eight years, the child's general practice medical records were scrutinized. At each time point, we recorded the date of any mention of an asthma diagnosis; a 'query' diagnosis was considered as 'non asthma' in this analysis. We also collected information on GPs' prescriptions for asthma (β2 agonists, inhaled corticosteroids, theophyllines, sodium cromoglycate); and noted the total annual number of visits to the GP for any reason. These data were available for 593 (92%) children up to eight years of age.

Analysis

Three main definitions of 'ever' asthma were available for analysis:

1. Parental opinion on 'ever' asthma (age 1—14).
2. Doctor's diagnosis of 'ever' asthma reported by the parent (age 1—14).
3. Diagnosis of asthma in GP record (up to age 3, 6, 8).

Other definitions of 'ever' and 'current' asthma were also considered in the analyses: treatment for asthma in GP record (up to age 3, 6, 8); parental opinion on current asthma (age 8, 14), treatment for asthma over the past year reported by the parent (age 8, 14); attendance at hospital or GP asthma clinic over the past year, reported by the parent (age 8, 14); days off school because of asthma over the past year, reported by parent (age 8, 14); current

wheeze over the past year (occasionally or most of the time, age 1–14).

We calculated the prevalence of each asthma definition reported at interview and in the GP record, focussing on three 'ever asthma' definitions. To analyse their concordance, both the percent of positive and negative agreements and Cohen's kappa statistics were calculated. Since information from GP records was available only to the age of 8 years, most of the analyses were focussed on cross-sectional and longitudinal 'ever asthma' definitions at or by this age.

Without a 'gold standard', the sensitivity and specificity of a given case definition cannot be calculated directly; thus the true disease state for each subject is unknown, or 'latent'. To compare the diagnostic values of the three definitions of 'ever asthma' we applied a latent class analysis (LCA)[16,17] in which it is assumed that any observed association between the tests is explained by the unobserved (latent) class variable, i.e. the true 'ever asthma' disease status (yes/no). This method allows estimation not only of disease prevalence, but also of the sensitivity and specificity of each of the three different case definitions; we used the "gllamm" program[18] in Stata 10.1 (Stata Corp., College Station, Texas, USA). In latent class analysis it is assumed that the results for each individual for a given disease status are independent (conditional independence). Unfortunately with three manifest variables and two latent classes, the model is 'just-determined' (the number of estimated parameters is the same as the degrees of freedom, df), so that, unless some additional restrictions are placed on estimated parameters, one cannot test conditional independence. To verify whether a lack of conditional independence could have influenced our estimates, a sensitivity analysis was performed fixing the prevalences of the two latent classes to some plausible values (15% and 22%) in order to free up some df. Subsequently, we checked the assumption of local independence by speculating that the standardized residuals as estimated from the LCA model for each response pattern from the 3 diagnostic tests should be between about -2 and 2.[19] We also checked the conditional dependence assumption using a modified version of Garrett and Zeger's Log-Odds Ratio check for detecting conditionally dependent items,[20] using the CONDEP programme.

Longitudinal consistency across the seven interviews of 'ever asthma' and a doctor's diagnosis (both as reported by parents) was studied; with two levels of response at seven time points, 2^7 ($=128$) different longitudinal patterns were possible by age 14. We elected, prior to analysis, to consider four possible patterns calculated at each time point: 'consistent negative ever asthma' (no 'ever asthma' responses at any age with previous congruent answers); 'consistent positive ever asthma' (yes 'ever asthma' response at any age, with previous congruent answers); 'inconsistent positive ever asthma' (yes 'ever asthma' response at any age, with at least 1 previous 'no' and 1 previous, incongruent 'yes'); 'inconsistent negative ever asthma' (no 'ever asthma' responses at any age, with at least 1 previous 'yes'). By definition, the sum of the consistent and inconsistent 'positive ever asthma' patterns corresponds to the cross-sectional estimate of 'ever asthma'.

Finally, we examined which characteristics might have influenced the accuracy of reported asthma and/or influenced the use of an 'asthma' label in treated or symptomatic children. The following child or parental characteristics were included in these analyses: the child's gender and birth order; the mother's age at delivery and her duration of education; the father's socio economic class based on his occupation[d]; a history of parental or sibling asthma, the latter restricted to children with at least 1 sister or brother; children's atopy, defined by the presence of $\geq$1 positive responses (mean weal 2 mm) to three common allergens (pollen mixture, *Dermatophagoides pteronyssinus* and cat fur)[15]; the child's general practice at the start of the project and the total number of visits to the GP they had made by the age of eight, expressed in quartiles; and, as a proxy of asthma severity, the frequency of GP visits for breathing difficulties and days off school due to asthma during the last 12 months as reported by the parent at the age eight interview. Associations between these characteristics and the accuracy of asthma definitions were tested in bivariate analyses using chi-squared tests. Analyses were undertaken using SAS 9.1 (SAS Institute, Cary, NC, USA) and Stata 10.1 software (Stata software version 10.1; Stata Corp., College Station, Texas, USA).

Results

In Table 1 are shown the cross-sectional prevalences of the various asthma labels at different ages. As expected, and with the exception only of a parental report of 'ever asthma', the prevalence estimates increased monotonically with age. At age one, the range of 'ever asthma' prevalence estimates was narrow, from 5.6% (doctor's diagnosis as reported by the parent) to 6.9% (parental opinion); at the age eight the range was wider, from 15.5% (parental opinion) to 21.5% (GP record). Up to the age of four years the parental opinion on asthma prevalence was higher than their report of a doctor's diagnosis; at older ages this pattern was inverted. At the age of eight, 165 children (28%) had at least one report of 'ever asthma' among the three considered, a proportion which rose to 35% when all reports at earlier interviews were considered (cumulative 'ever asthma'). Based on each of the several labels for 'ever' asthma and a parental report of wheeze over the previous 12 months, at the age of 8 years, about 9% of children had current, symptomatic asthma (Table 1).

Cross sectional agreement

There was, overall, a moderately close agreement (overall agreement 89–96%; kappa 0.55–0.78) between parental opinions and parental reports of a doctor's diagnosis of 'ever asthma' at each interview. In contrast, parental reports of a doctor's diagnosis and the evidence from the GP record showed slightly poorer agreement (overall agreement 86–93%; kappa 0.42–0.63) (data not shown).

[d] Categorized as: I/II (professional, managerial and technical), III (skilled), IV/V (partly skilled, unskilled).

Table 1 Cross-sectional and cumulative prevalence of 'ever asthma' and 95% Confidence Interval (CI) using several definitions, by child's age.

	Age, years	1	2	3	4	5	8	14
	Number of interviewed children	623	617	615	611	604	593	496
	n (%; CI 95%)							
'ever' asthma	Parental opinion	43 (6.9; 4.9–8.9)	57 (9.2; 7.0–11.5)	93 (15.1; 12.3–18.0)	108 (17.7; 14.7–20.7)	99 (16.4; 13.4–19.3)	92 (15.5; 12.6–18.4)	88 (17.7; 14.4–21.1)
	Parental report of doctor's diagnosis	35 (5.6; 3.8–7.4)	52 (8.4; 6.2–10.6)	79 (12.9; 10.2–15.5)	110 (18.0; 15.0–21.1)	118 (19.5; 16.4–22.7)	126 (21.3; 18.0–24.5)	115 (23.1; 19.4–26.7)
	GP record	39 (6.5; 4.5–8.4)	62 (10.3; 7.9–12.7)	69 (11.4; 8.9–14.0)	106 (17.8; 14.8–20.9)	120 (20.2; 16.9–23.4)	126 (21.5; 18.2–24.9)	NA
	≥1 of above-cross-sectional[a]	68 (11.4; 8.8–13.9)	100 (16.7; 13.7–19.7)	131 (21.8; 18.5–25.1)	157 (26.4; 22.9–30.0)	160 (27.0; 23.4–30.6)	165 (28.4; 24.7–32.1)	NA
	≥1 of above-cumulative[a]	68 (11.4; 8.8–13.9)	112 (18.7; 15.6–21.8)	146 (24.3; 20.9–27.7)	191 (31.7; 28.0–35.5)	201 (33.4; 29.6–37.2)	213 (35.3; 31.5–39.1)	NA
'ever' treatment/ wheeze	β2 agonist in GP record	183 (30.3; 26.7–34.0)	219 (36.3; 32.5–40.2)	221 (36.6; 32.8–40.5)	221 (37.3; 33.4–41.2)	276 (46; 42.0–50.0)	281 (47.0; 43.0–51.0)	NA
	Inhaled steroid in GP record	21 (3.5; 2.0–5.0)	37 (6.1; 4.2–8.1)	39 (6.5; 4.5–8.4)	89 (15.0; 12.1–17.9)	101 (17.0; 14.0–20.1)	110 (18.8; 15.7–22.0)	NA
	Any asthma treatment[b] in GP record	176 (29.2; 25.6–32.8)	225 (37.3; 33.5–41.2)	229 (38.0; 34.1–41.9)	223 (37.6; 33.7–41.5)	283 (47.2; 43.2–51.2)	290 (48.5; 44.5–52.5)	NA
	Parental report of wheeze	267 (42.9; 39.0–46.7)	320 (51.2; 47.3–55.1)	347 (55.5; 51.6–59.4)	367 (58.7; 54.9–62.6)	379 (60.6; 56.8–64.5)	386 (61.8; 58.0; 65.6)	NA
Parental report for last 12 months	'Asthma'	NA	NA	NA	NA	NA	48 (8.1; 5.9–10.3)	58 (11.7; 8.8–14.5)
	Asthma treatment	NA	NA	NA	NA	NA	42 (7.1; 5.0–9.2)	32 (6.4; 4.3–8.6)
	Wheeze	267 (42.9; 39.0–46.7)	189 (30.6; 27.0–34.3)	171 (27.8; 24.3–31.4)	132 (21.6; 18.3–24.9)	108 (17.9; 14.8–20.9)	79 (13.3; 10.6–16.1)	
'ever' asthma with wheeze in last 12 months	Parental opinion	43 (6.9; 4.9–8.9)	53 (8.6; 6.4–10.8)	80 (13.0; 10.4–15.7)	46 (7.8; 5.6–9.9)	71 (11.8; 9.2–14.3)	52 (8.8; 6.5–11.0)	
	Parental report of doctor's diagnosis	34 (5.5; 3.7–7.2)	42 (6.8; 4.8–8.8)	63 (10.3; 7.9–12.7)	81 (13.3; 10.6–15.9)	69 (11.4; 8.9–14.0)	54 (9.1; 6.8–11.4)	
	GP record	33 (5.5; 3.7–7.3)	42 (7.0; 5.0–9.0)	48 (8.0; 5.8–10.1)	76 (12.8; 10.1–15.5)	60 (10.1; 7.7–12.5)	51 (8.8; 6.5–11.1)	
	≥1 of above-cumulative	61 (10.2; 7.8–12.6)	75 (12.5; 9.9–15.2)	97 (16.2; 13.2–19.1)	110 (18.4; 15.3–21.5)	87 (14.6; 11.8–17.5)	64 (10.9; 8.4–13.5)	

[a] Denominators may change due to different missing values at several ages.
[b] Beta 2 agonist, inhaled steroid, sodium cromoglycate, other asthma medications.

Full agreement between the three decreased as children got older (91% at age one, 83% at age eight) as did negative agreements (89% at age one, 72% at age eight). The proportion of children identified only by one source as ever having had asthma was stable over time but showed high internal heterogeneity. At the age of eight, 35 children (6%) had been 'labelled' as asthmatic only by their GP, 20 (3.4%) had only a doctor's diagnosis reported by the parent and for three (0.5%) the parental opinion was the only source of diagnosis (Fig. 1). The estimated prevalence of current asthma using a doctor diagnosis of ever asthma plus current symptoms (wheezing in the last 12 months) and current asthma reported by the parents were respectively 9.1% and 8.1% (Table 1). There was, a close agreement between these two definitions: overall agreement 96.0%; kappa 0.74.

When results from the three sources were combined using LCA, the prevalence of 'ever asthma' at age eight was estimated to be 19.3%. The comparison of the predicted counts with those observed indicated that the model had a good fit. Parental opinion had the highest specificity (99.4%) but a relatively low sensitivity (78.8%). A record of 'ever asthma' in the GP record had the lowest specificity (92.3%) and sensitivity (76.8%), in contrast to the sensitivity and specificity of a parental report of a doctor's diagnosis, respectively 97% and 96.6%. After fixing the prevalence of ever asthma at either 15% or 22% a doctor's diagnosis of ever asthma reported by the parents remained the most specific and sensitive source and conditional independence was not violated.

The 58 children who, at the age of eight, had had a diagnosis of 'ever asthma' from only a single source were compared with the 107 children with a diagnosis from at least two sources. No demographic or family characteristics (gender; birth order; mother's age and education; father's socio economic class; parental or sibling asthma) were significantly different between the two groups; nor did we find any difference in the general practice at which the child was registered. Variables indicative of asthma severity, the numbers of school sick days and asthma clinic visits in the previous 12 months, were more frequent in children with agreement from at least two sources (22.4%, 26.4%) than in children with only one (1.7%, 6.9%). Similarly, total visits to the GP were more frequent among children with two sources of an 'ever asthma' label compared to children with just one, 57.4% and 29.3% of such children fell in the upper, 4thquartile of visits ($p = 0.004$) (data not shown).

Longitudinal consistencies

Fig. 2(a) and (b) displays the longitudinal consistency across the seven interviews for 'ever asthma' defined by parental opinion and parental report of a doctor's diagnosis. Using the former, at the age of eight 73% of children had consistently been defined as never having had asthma and 12.8% consistently as 'ever' asthmatic; an additional 2.6% would have been classified as 'ever asthmatic' (and 12% as 'never asthmatic') if previous interview information had not been taken into account. The proportions of total inconsistencies (positive plus negative) increased with children's age — by definition — reaching 16% by the age of 14 years. These inconsistencies were fewer (10% by the age of 14) for parental reports of a doctor's diagnosis.

We explored these longitudinal inconsistencies at the age of eight years by comparing those children with consistently positive labels ($n = 75$ for parental opinion, $n = 110$ for parental report of a doctor's diagnosis) with children whose labels were inconsistent ($n = 85$ and $n = 50$, respectively). As above, no demographic or family characteristics were significantly associated with longitudinal consistency of (non-)asthma definition; but measures indicative of asthma severity by age eight were more

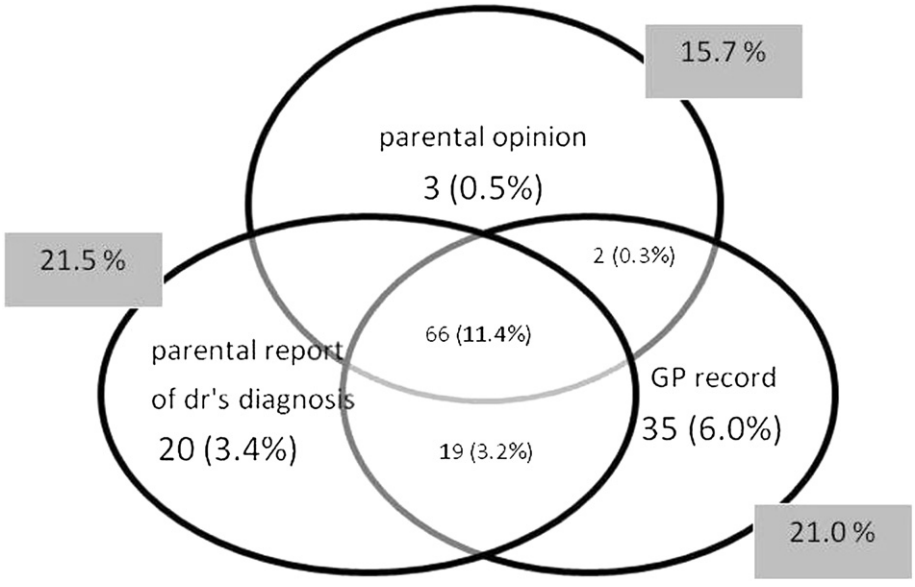
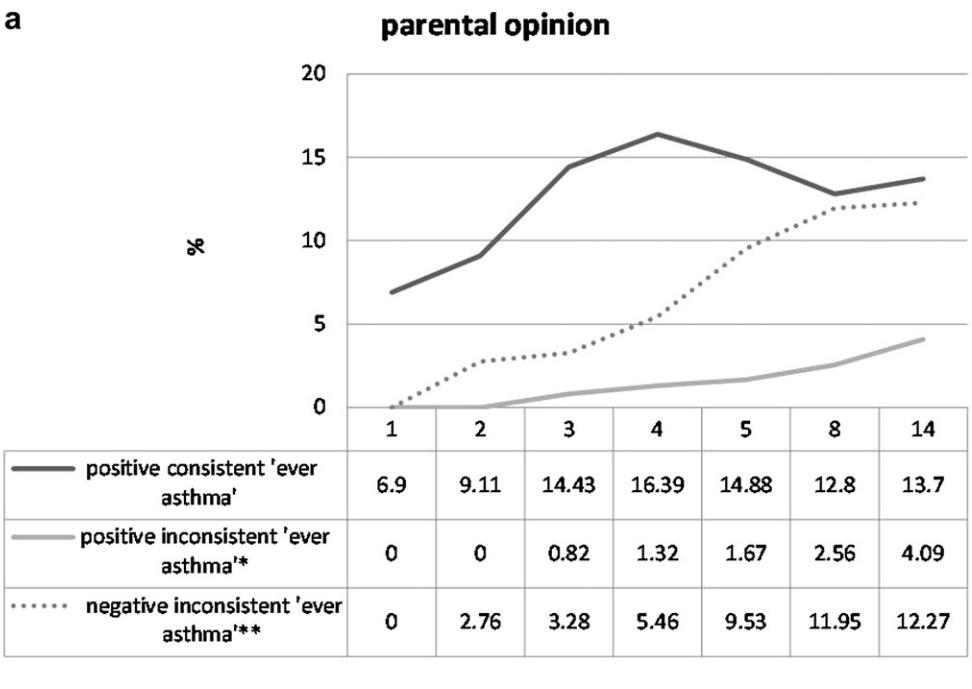
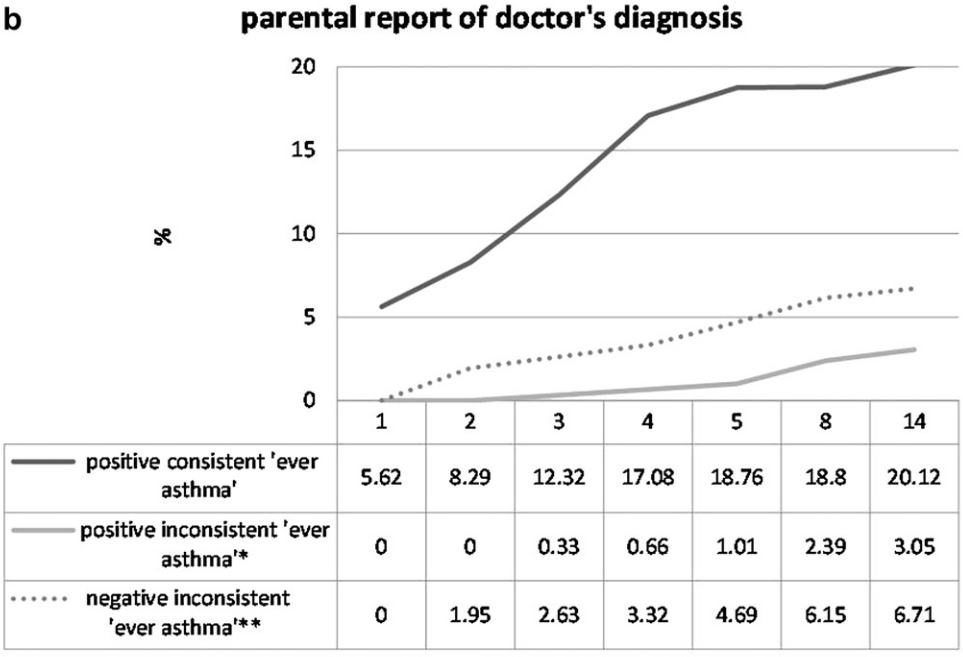


Figure 1 Venn diagram displaying agreement between 'ever asthma' from parental opinion, parental report of doctor's diagnosis and GP record, at age eight.



	1	2	3	4	5	8	14
positive consistent 'ever asthma'	6.9	9.11	14.43	16.39	14.88	12.8	13.7
positive inconsistent 'ever asthma'*	0	0	0.82	1.32	1.67	2.56	4.09
negative inconsistent 'ever asthma'**	0	2.76	3.28	5.46	9.53	11.95	12.27



	1	2	3	4	5	8	14
positive consistent 'ever asthma'	5.62	8.29	12.32	17.08	18.76	18.8	20.12
positive inconsistent 'ever asthma'*	0	0	0.33	0.66	1.01	2.39	3.05
negative inconsistent 'ever asthma'**	0	1.95	2.63	3.32	4.69	6.15	6.71

*'yes' at the estimate age, at least 1 previous 'no' and 1 previous 'yes'
**'no' at the estimate age, at least 1 previous 'yes'

Figure 2 Longitudinal consistency of 'ever' asthma by age of interview.

common in those with consistently positive labels. A child's atopy was significantly associated with longitudinal inconsistency in ever asthma reported by the parents, but not significantly in a parental report of a doctor's diagnosis (Table 2).

Characteristics associated with an 'asthma' label

Of the 289 children who had received a prescription for asthma at least once by the age of eight, 194 (67.1%) had had a diagnosis of asthma (cumulative definition in at least one of the three sources above). By the same age, a total of 374 (62%) children had experienced at least one year with wheeze reported by their parent; 198 (52.9%) of these had also been labelled as 'ever asthmatic' at least once by the parent and/or GP. In Table 3 we display associations between demographic and other characteristics and cumulative 'ever asthma' diagnosis in treated and symptomatic children by the age of eight years. Both treated and symptomatic children who had had a label of asthma were

Table 2 Association between children/parents' characteristics and longitudinal inconsistencies on the label of 'ever asthma' (mother and doctor reported by the mother), by the age of 8.

	Mother opinion ever asthma			Dr diagnosis reported by the mother		
	Positive consistent ($n = 75$) *N.* (%)	Inconsistent ($n = 85$) *N.* (%)	*P*-value	Positive consistent ($n = 110$) *N.* (%)	Inconsistent ($n = 50$) *N.* (%)	*P*-value
Child's gender Female	25 (33.3)	38 (44.7)	0.14	40 (36.4)	23 (46)	0.25
Birth order						
First child	31 (41.3)	34 (40)		52 (47.3)	18 (36)	
Second child	24 (32)	34 (40)		32 (29.1)	19 (38)	
Third child +	20 (26.7)	17 (20)	0.48	26 (23.6)	13 (26)	0.38
Mother age delivery						
<25	15 (20)	22 (25.9)		26 (23.6)	16 (32)	
25–29	32 (42.7)	37 (43.5)		50 (45.4)	19 (38)	
30+	28 (37.3)	26 (30.6)	0.57	34 (30.9)	15 (30)	0.50
Maternal education + 16 years						
None	40 (53.3)	32 (38.1)		54 (49.1)	26 (52)	
<2 years	9 (12)	18 (21.4)		13 (11.8)	4 (8)	
2+ years	26 (34.7)	34 (40.5)	0.11	43 (39.1)	20 (40)	0.76
Socio economic class[a]						
I/II	20 (30.8)	21 (28.4)		33 (36.3)	8 (17.4)	
III	29 (44.6)	32 (43.2)		37 (40.7)	22 (47.8)	
IV/V	16 (24.6)	21 (28.4)	0.88	21 (23.1)	16 (34.8)	0.06
Mother asthmatic Yes	18 (24)	16 (18.8)	0.42	25 (22.7)	9 (18)	0.50
Father asthmatic Yes	15 (20.3)	16 (18.8)	0.81	23 (21.1)	9 (18)	0.65
At least one sibling asthmatic Yes	32 (45.7)	25 (32.9)	0.11	38 (38.0)	15 (32.6)	0.53
Child atopic[b] Yes	30 (42.3)	14 (17.9)	0.001	33 (31.7)	8 (17.4)	0.07
GP practice						
1	20 (26.7)	24 (28.2)		26 (23.6)	15 (30)	
2	28 (37.3)	33 (38.8)		41 (37.3)	14 (28)	
3	25 (33.3)	26 (30.6)		40 (36.4)	21 (42)	
4	2 (2.7)	2 (2.3)	0.98	3 (2.7)	0 (0)	0.38
N GP's visits						
1 Q	2 (2.9)	7 (8.9)		5 (4.8)	6 (12.5)	
2 Q	15 (21.4)	16 (20.2)		17 (16.3)	17 (35.4)	
3 Q	13 (18.6)	19 (24.0)		26 (25)	10 (20.8)	
4 Q	40 (57.1)	37 (46.8)	0.318	56 (53.8)	15 (31.2)	0.008
Sick days off school last 12 months						
Yes	20 (26.7)	4 (4.7)	<0.001	21 (19.1)	3 (6)	0.03
GP asthma clinic last 12 months						
Yes	23 (30.7)	6 (7.1)	<0.001	25 (22.7)	4 (8.2)	0.03

[a] Categorized as: I/II (professional, managerial and technical), III (skilled), IV/V (partly skilled, unskilled).
[b] ≥1 positive response (mean weal 2 mm) to three common allergens (pollen mixture, *Dermatophagoides pteronyssinus* and cat fur; ALK, Abelló, UK) at the age of 8.

significantly more likely to have parents or sibling(s) with asthma, to be atopic to be registered with a specific general practice, to have had a high number of total GP and asthma clinic visits and to have had sick days off school.

Discussion

The primary aim of these analyses was to compare different definitions or labels of asthma in children reported by their parents or detected through examination of their general practice medical record; and to identify characteristics that might have influenced the accuracy of these definitions. Although the estimates of prevalence were quantitatively similar for parental reports and GP records (in particular up to the age of four), agreement between the three sources in particular cases was less than expected; but appeared to be unrelated to specific socio-economic characteristics. The findings of our latent class analysis suggest that a parental report of a doctor's diagnosis was the most sensitive and specific source of asthma definition. It appears that parents more accurately remember a doctor's diagnosis than their own previously reported opinion on their child's asthma.

In our study, 35% of children *by* the age of eight years had at least one reported 'label' of asthma, reflecting both cross sectional disagreement and longitudinal inconsistencies between the three sources of asthma labels. Six

Table 3 Association between children/parents' characteristics and 'ever asthma label', among 289 children with at least 1 asthma medication in GP's notes and 374 children with at least 1 year of experienced wheeze, by the age of 8.

	Children with at least 1 asthma medication by the age of 8			Children with at least 1 experienced wheeze by the age of 8		
	None label (n = 95) *N.* (%)	At least 1 label (n = 194) *N.* (%)	*P*-value	None label (n = 176) *N.* (%)	At least 1 label (n = 198) *N.* (%)	*P*-value
Child's gender Female	43 (45.3)	76 (39.2)	0.32	83 (47.2)	79 (39.9)	0.16
Birth order						
First child	35 (36.8)	78 (40.2)		67 (38.1)	80 (40.4)	
Second child	39 (41.0)	69 (35.6)		66 (37.5)	71 (35.9)	
Third child +	21 (22.1)	47 (24.2)	0.66	43 (24.4)	47 (23.7)	0.90
Mother age delivery						
<25	20 (21.0)	52 (26.8)		46 (26.1)	54 (27.3)	
25–29	36 (37.9)	75 (38.7)		72 (40.9)	76 (38.4)	
30+	39 (41.0)	67 (34.5)	0.45	58 (32.9)	68 (34.3)	0.88
Maternal education + 16 years						
None	42 (44.2)	84 (43.5)		80 (46.2)	90 (45.7)	
<2 years	17 (17.9)	32 (16.6)		31 (17.9)	29 (14.7)	
2+ years	36 (37.9)	77 (39.9)	0.93	62 (35.8)	78 (39.6)	0.63
Socio economic class[a]						
III	47 (53.4)	79 (48.5)		90 (55.9)	75 (44.9)	
IV/V	11 (12.5)	40 (24.5)	0.07	35 (21.7)	43 (25.7)	0.13
Mother asthmatic Yes	10 (10.5)	41 (21.1)	0.03	27 (15.3)	44 (22.2)	0.09
Father asthmatic Yes	6 (6.3)	38 (19.7)	0.003	17 (9.7)	39 (19.8)	0.01
At least one sibling asthmatic Yes	15 (17.9)	62 (36.9)	0.002	36 (23.5)	65 (37.6)	0.006
Child atopic[b] Yes	16 (18.4)	46 (27.1)	0.12	24 (15.0)	43 (25.2)	0.02
GP practice						
1	42 (44.2)	54 (27.8)		66 (37.5)	54 (27.3)	
2	38 (40)	72 (37.1)		71 (40.3)	74 (37.4)	
3	15 (15.8)	65 (33.5)		39 (22.2)	66 (33.3)	
4	0 (0)	3 (1.6)	0.003	0 (0)	4 (2.0)	0.01
N GP's visits						
1 Q	17 (18.7)	10 (5.7)		48 (28.7)	14 (7.9)	
2 Q	21 (23.1)	37 (21.3)		46 (27.5)	37 (21.0)	
3 Q	28 (30.8)	44 (25.3)	<0.001	44 (26.3)	42 (23.9)	<0.001
4 Q	25 (27.5)	83 (47.7)		29 (17.4)	83 (47.2)	
Sick days off school last 12 months						
Yes	0 (0)	25 (13.6)	<0.001	0 (0)	24 (12.8)	<0.001
GP asthma clinic last 12 months						
Yes	1 (1.1)	32 (17.5)	<0.001	3 (1.8)	30 (16.0)	<0.001

[a] Categorized as: I/II (professional, managerial and technical), III (skilled), IV/V (partly skilled, unskilled).
[b] ≥1 positive response (mean weal 2 mm) to three common allergens (pollen mixture, *Dermatophagoides pteronyssinus* and cat fur; ALK, Abelló, UK) at the age of 8.

percent of children had an asthma diagnosis recorded in their GP notes which was not confirmed by a parental report; these children were broadly similar to those with a parental asthma label, but appeared to have less severe asthma, as measured by attendance at an asthma clinic and school absence for asthma, and had a lower number of total GP visits. We found no association with a particular general practice.

Neither cross-sectional nor longitudinal inconsistencies, the latter being previously unstudied, were related to socio demographic characteristics but measures indicative of more severe asthma, including the total number of GP visits, were associated with fewer inconsistencies and disagreements. A recent study that compared a range of parental reports and medical records in US farm children found, as we did, that although prevalence estimates based on a past asthma diagnosis were quantitatively similar, agreement between the two sources was less than expected.[10]

Similarly, a population-based survey of preschool-aged children in the US revealed substantial inconsistency (kappa = 0.48) in information about asthma based on medical record's data and maternal reports of a doctor diagnosis.[8] In contrast to our findings, in a US population, concurrence rates were lower for children from poor, less educated, and Hispanic families.[9]

A secondary aim of this analysis was an examination of variables that might influence the use of an 'asthma' label

in children with wheeze or receiving anti-asthma treatments; our purpose was to understand whether there was substantial confounding by characteristics apart from the disease itself that might bias future analyses. About a third of children had been prescribed an asthma treatment and been wheezy at least once without attaining a label of asthma. This finding is compatible with that from a recent study suggesting that most adolescents with 'ever wheezing' had not been diagnosed with asthma.[21] In Ashford, a family (parental or sibling) history of asthma, more severe disease, a greater number of total GP visits and registration with specific practices each increased the likelihood of a wheezy or treated child having a label of 'asthma', associations that have been reported previously.[11,22–24] However we failed to find any statistically significant relationships to socio-demographic characteristics or to gender. This is in contrast to the finding in US children that symptomatic children from poor backgrounds were less likely to have had an asthma diagnosis[13]; and to the finding in that study and elsewhere[12,13] that girls are similarly disadvantaged. More similar were the findings of a UK survey suggesting that the likelihood of being labelled with asthma was higher in those with a parental history of hayfever, but not obviously determined by socio economic characteristics.[11]

We used LCA to estimate and compare the sensitivity and specificity of three definitions of ever asthma without a gold standard test. Despite its advantages there are some limitations to this approach, in particular with regard to the assumption of conditional independence and the number of tests used to estimate the 'true' disease status. In order to make a latent class model estimable, the number of diagnostic tests used on the study sample must provide at least as many degrees of freedom as the number of parameters to be estimated, implying that at least three tests are requested. However, LCA performs substantially better when more than ten tests are applied.[25] In order to verify the lack of conditional independence we carried out some sensitivity analyses that showed a good model fit and that the assumption of local independence of the three diagnostic tests held here.

Our findings are based on study of a representative cohort of English children born 17 years ago. Through the goodwill of the cohort families and their GPs, we have been able to maintain high rates of follow-up and the associations we report are likely to be generalizable to other British populations. Moreover they are likely to be representative of all children, rather than a group selected to be at high risk of asthma; the Ashford cohort is unusual in that the size and nature of its population base is firmly established. Any wider generalization may be less secure, especially to settings with very different systems of health care provision; asking a parent about a doctor diagnosis of asthma may be less relevant in resource-poor parts of the world where access to medical care is limited; since our sample size was relatively small, some analyses may have been underpowered. Because this study was located in a single town, we can't be confident that diagnostic practice in Ashford was similar to the rest of the UK, or other countries. The estimated proportion of Ashford children who had ever had asthma at the age of eight ranged, according to the definition used, from 15 to 20%. In the international Study of Asthma and Allergies in Childhood (ISAAC) the prevalence of ever asthma in UK children aged 6–7 years was 22%, the highest among all participating centres.[26,27]

For population-based studies that aim to establish childhood disease prevalence, including those studying spatial or temporal variations, a parental report of a doctor's diagnosis of asthma is sensitive, specific, longitudinally consistent and not subject to large socioeconomic bias. Moreover, it has the inestimable advantage of being cheap and readily applied.

Conflict of interest

All named authors have read the manuscript, approved it and have participated in the study to a sufficient extent to be named as authors. Neither financial nor other relationships might lead to conflict of interests.

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