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Wheeze in preschool children and its relation with doctor diagnosed asthma

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Abstract

Objective **– To describe the characteristics of wheeze and its relation with doctor diagnosed asthma in children aged 5 years and under.**

Design **– Questionnaire survey of population based random sample of children registered on Leicestershire Health Authority's child health index for immunisation; questionnaire completed by parents.**

Subjects **– 1650 white children born in 1985 to 1989 who were surveyed in 1990.**

Main outcome measures **– Age distribution, severity, precipitants, seasonal characteristics, and diurnal variation of wheeze, family history of asthma/atopy, and their association(s) with doctor diagnosed asthma.**

Results **– There were 1422 replies (86·2%). Two hundred and twenty two (15·6%) were reported to have wheezed and of these 121 (8·6%) had formally been diagnosed as having asthma. More than 80% of the former had recurrences of wheeze and 40% (72) had three or more episodes in the preceding 12 months. Age, number of episodes per year, the severity of shortness of breath with attacks, and precipitants other than colds were the major factors determining the probability that a wheezy child will be diagnosed as having asthma. The data also suggest that despite the strong association of symptom based criteria with the label asthma, asthma was not diagnosed by these same severity criteria in one quarter of cases.**

Conclusions **– Clinical and physiological follow up studies of children identified as asthmatic by the above criteria during the preschool years should validate or refute the predictive value of these measures of wheeze severity.**

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Wheeze affects some 20% of children,[1–3] yet few studies have described its characteristics.[4] Most prevalence studies have been conducted in schoolchildren, and descriptions of symptoms in the preceding preschool years have consequently been dependent upon parental recall over a relatively long period of time.[5–7] This recall is incomplete and strongly influenced by the frequency and persistence of symptoms in the child.[8] The few studies that have described the characteristics of wheeze in children have focused on the severity[4 8] and precipitants of attacks.[2 9 10]

We have recently reported the cumulative incidence of wheeze and doctor diagnosed asthma in preschool children.[11] Asthma had been diagnosed in 11%, including 2·1% with cough as the sole symptom. The characteristics of wheeze in these preschool children and the relation of wheeze with doctor diagnosed asthma is the subject of this paper. As there are no objective tests of airways reversibility that can be readily applied to this preschool age group we felt it was important to delineate the relationship between the pattern of wheezing and the diagnostic label of asthma. By studying children under 5 years old we hoped to facilitate an accurate description of the nature of wheeze in this age group as it may be reasonably assumed that parental recall is more reliable over the relatively short period of time between the onset of symptoms and the date of investigation.

Subjects and methods

The subjects were white children aged 5 years and under who were recruited between April and July 1990 as a population based stratified random sample utilising the Leicestershire Health Authority child health index as the sampling frame. There were 1422 (86·2%) replies to 1650 postal questionnaires. Stratification was by year of birth to ensure equal representation of each year cohort from 1985 to 1989. The study population of 1422 was represented from these years of birth by 290, 280, 282, 289, and 281 children respectively. Of the 1422 children 222 (15·6%) reported wheeze among whom 126 (8·86%) had been diagnosed to have asthma. Wheezing was defined for the parents as a high pitched musical or whistling sound coming from the chest during breathing, not from the throat. Its presence was detected by the question 'Has your child ever had attacks of wheezing?'. Parents who answered positively to this inquiry were then asked to complete questions (table 1) taken from previously validated questionnaires,[12–14] describing wheeze severity, precipitants, seasonal conditions, diurnal variation, and family history (first degree relatives) of asthma, eczema, and hay fever. The question on the presence of wheeze was assessed for repeatability on a subgroup of 100 from the total pool of respondents and was found to be highly reproducible. This and other outcomes assessed for reproducibility have been reported.[11] However, the temporal nature of some of the questions on wheeze severity made assessment of reproducibility impracticable. Closed grouped formats were used for the

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Table 1 Questions used in the questionnaire to identify and describe wheeze and to identify diagnosed asthma

Has your child ever had attacks of wheezing?	
During the past 12 months, how many attacks of wheezing has (s)he had?	
During the past 12 months, on average how long do these attacks last?	
How long is it since his/her last attack of wheezing?	
Do these attacks cause him/her to be short of breath?	
Do these attacks occur:	when (s)he has a cold?
	occasionally apart from colds?
	when (s)he is running or playing?
	with eating or drinking?
	when (s)he is near animals, dust or grass, etc?
Do these attacks occur more frequently at a particular time of year?	
Is the wheezing worse at a particular time of day?	
Has any doctor or hospital told you that (s)he has asthma?	
Has your (father, mother, and siblings separately) ever suffered from any of the following conditions:	asthma?
	bronchitis?
	eczema?
	hay fever?
	other chest conditions?

answers to each question in order to facilitate accurate recall and analysis. For example, the response alternatives to the question on the total number of attacks were: none, 1–2, 3–5, 6–10, 11–20, and more than 20, and to the questions on shortness of breath: yes always, yes occasionally, and no never.

Inquiry was made about suspected precipitants: colds and others apart from colds (non-cold precipitants). Specific non-cold precipitants were also sought: running or playing (exercise); foodstuffs (ingestants), and aeroallergens such as pollens or epithelia (inhalants). Those who responded positively to the question on seasonal variation were asked to identify the 'bad' months so as to differentiate between winter (October to March) and summer (April to September). Those with diurnal variation were asked to indicate whether symptoms were worse during the day or at night. Finally, questions relating to asthma, eczema, and hay fever in parents and siblings were posed as indicators of family asthma/atopy status.

Statistical analysis was carried out using the SAS statistical software package.[15] Tests of bivariate association between categorical variables were based upon the χ^2 test for homogeneity (without continuity correction). Where appropriate the χ^2 test for trends was used to investigate systematic changes in the distribution of a binary variable across the ordered categorical levels of an ordinal variable. The contributions of individual measures of wheeze severity to a nominated binary endpoint, doctor diagnosed asthma, were assessed as follows.

Because the individual measures of asthma severity and the responses to different precipitants are all likely to be correlated with one another, unconditional logistic regression modelling was used to investigate the multivariate relationship between these various symptom based criteria and the probability that a wheezy child will be formally diagnosed as having asthma. Modelling was performed in S-plus using the 'glm' function[16] and was restricted to those children who were known to wheeze and for whom it was also known that the date of diagnosis of asthma did not precede the date of onset of wheezing. Doctor diagnosed asthma was used as the binary response variable (0=without, 1=with) and variables relating to the potentially important symptom based criteria listed on table 2 entered the model as categorical explanatory covariates. Model construction was based upon the systematic removal of covariates from an initial model containing all main effects. Formal tests for the significance of the deterioration of fit following the removal of the regression terms relating to a specific variable were based upon the likelihood ratio test.[17]

Table 2 Factors investigated in the regression modelling of wheeze severity factors and doctor diagnosed asthma

Gender
Age group
The total number of attacks
The frequency of attacks within the last year
The average duration of attacks
The length of time since the last attack
The presence of shortness of breath with attacks
Colds as a precipitant
Any precipitants other than colds
Exercise as a precipitant
Eating as a precipitant
Dust as a precipitant
Seasonal variation
Diurnal variation
Asthma in first degree relatives

In the process of modelling, it rapidly became clear that the probability of doctor diagnosed asthma was similar for children with 3–5, 6–10, and >10 attacks per year and the original five level covariate was therefore collapsed to three levels: 0=no attacks in the last year, 1=1–2 attacks, 2=3+attacks.

Before drawing definitive conclusions the final model was subjected to standard model checking procedures, including tests for non-linearity and interaction, the analysis of Pearson residuals and the investigation of leverage.[17]

The principal analysis included age on the completion of the questionnaire as a five level categorical variable taking values: 0 (<1 year), 1 (1 year <2 years), ... 4 (age 4 years). A further model was constructed using precise decimal age and age,^{2} but the principal inferences arising from this additional model were qualitatively so similar to those from the original analysis that only the latter is presented.

Results

SEVERITY OF WHEEZE

Eighteen per cent (40/221) of wheezy children had had only one episode but children in the youngest age group were perhaps too young to have had a large number of subsequent attacks. Overall, 18% (40/221) had 1–2 further attacks, 30% (67/221) 3–5, 17% (38/221) 6–10, and 16% (26/221) had >10 further attacks. One in 10 children had experienced more than 20 attacks of wheeze. There was no significant change in year by year distribution of wheezy episodes (p=0·4).

In considering the number of attacks in the preceding 12 months the youngest age band was excluded from analysis. As with the age distribution for total number of attacks the distribution of attacks within the previous year did not differ significantly on year by year analysis (p=0·6). Overall, 22% (43/195)

Table 3 Distribution (row percentages (number)) of wheezy episodes in the 12 months before questionnaire by age band

Age (years)	No	No of attacks 0	1–2	3–5	6–10	>10
1	41	4·9 (2)	36·6 (15)	41·5 (17)	7·3 (3)	9·7 (4)
2	43	25·6 (11)	34·9 (15)	20·9 (9)	11·6 (5)	7·0 (3)
3	45	31·1 (14)	37·8 (17)	17·8 (8)	11·1 (5)	2·2 (1)
>4	66	24·2 (16)	36·4 (24)	19·7 (13)	13·6 (9)	6·1 (4)
Total	195	22·1 (43)	36·4 (71)	24·1 (47)	11·3 (22)	6·2 (12)

χ^2=17·125, df=12, p=0·145.

had had no wheezing episode in the preceding 12 months. Thirty six per cent (71/195) had 1–2, 24% (47/195) 3–5, and nearly 18% (34/195) ≥6 attacks (table 3).

There were 152 replies to the question relating to the length of attacks of wheeze during the preceding 12 months. Overall, 18% (28/152) of attacks lasted up to one day, 48% (71/152) two to three days, 27% (41/152) four to seven days, and 8% (12/152) more than seven days. The distributions were similar in each of the age bands considered (p=0·42).

In considering the time since the last attack many children in the younger two age bands were not old enough to answer the last question alternative, >13 months. The distribution of replies from children in the older age bands shows that 48% (74/154) had their last attack in the preceding three months and that over 20% (36/154) had had no attack for over a year. The pattern was similar for each age band considered.

Shortness of breath with attacks of wheeze was reported in two thirds of the whole population, and was an invariable accompaniment in about one quarter (table 4). The reported rate of occasional shortness of breath did not change with age, but shortness of breath with every wheezing attack increased significantly with age (p=0·04).

PRECIPITANTS OF WHEEZE

Table 5 shows that about 90% of the children who wheezed had attacks that were reported to be brought on by colds, without significant birth year by year cohort effect (p=0·9). Wheeze associated with precipitants other than colds was less common particularly in the two youngest age groups. In exercise induced wheeze the extremely low rate in the children under 1 year almost certainly reflected the fact that most of these children were not then ambulant. Attacks of wheeze precipitated by ingestion of food or drinks occurred in only 5·9% of respondents.

Table 4 Distribution (row percentages (number)) of shortness of breath with wheeze attacks by age band

Age (years)	No	Short of breath with wheeze: Never	Occasionally	Always
0	27	37·0 (10)	40·7 (11)	22·2 (6)
1	40	52·5 (21)	35·0 (14)	12·5 (5)
2	43	27·9 (12)	55·8 (24)	16·3 (7)
3	45	28·9 (13)	40·0 (18)	31·1 (14)
>4	66	25·8 (17)	43·9 (29)	30·3 (20)
Total	221	33·0 (73)	43·4 (96)	25·5 (52)

χ^2=14·13, df=8, p=0·08.

Positive responses to all precipitants were greater for girls than boys when the sexes were assessed separately, although the differences were significant only for exercise. Exercise was a reported precipitant for wheeze in 24% (27/113) boys and 38% (33/86) girls (p=0·03).

SEASONAL AND DIURNAL VARIATIONS

The first year age group was omitted from analysis as many children in it were too young to have exhibited seasonal variation in symptoms. Of 195 children with wheeze in the four older age bands, 33% (64/195) had more attacks at a particular time of year: 86% (55/64) in winter. The patterns were similar for each of the older age groups. There was a significant association between seasonal variation of wheeze and the diagnosis of asthma (p=0·005).

Sixty one per cent (135/220) of all wheezers reported diurnal variation, of whom 91% (123/135) had nocturnal symptoms. There was a significant association between diurnal variation and the diagnosis of asthma (p=0·04) due almost entirely to the association with night time wheeze (p=0·02).

FAMILY HISTORY OF ASTHMA AND ATOPY

One hundred and twenty one (54·4%) of the 222 wheezy children gave a history of asthma in parents or siblings, and 164 (73·9%) a family history of atopic disorders (asthma, eczema, hay fever). Univariate analysis showed that a significantly greater proportion of wheezy children with a family history of asthma were diagnosed as having asthma (60·8% *v* 46·4%; p=0·032). A comparable but non-significant trend was observed for atopic disorders including asthma, p=0·081.

CHARACTERISTICS OF WHEEZE AND THE LIKELIHOOD OF ASTHMA BEING DIAGNOSED

Table 6 details the final unconditional logistic regression model quantifying the multivariate logistic regression relationship between the measures of asthma severity, the pattern of precipitants and the probability that a wheezy preschool child will be diagnosed as having asthma. The important factors that appear to determine this probability are age, the number of attacks a year, severity of shortness of breath during attacks, and precipitants other than colds. Rather surprisingly, seasonal and diurnal variations of wheeze, and a history of asthma in first degree relatives did not increase the likelihood of asthma being diagnosed when these factors were subjected to multivariate analysis. To take an example, a wheezy child aged 3 who has fewer than one attack a year, no shortage of breath during attacks, and no precipitants other than colds has an odds of $e^{(-3·724+1·286)}$=0·086 which is equivalent to a probability of 8% (0·086÷(1+0·086)=0·08) of having been diagnosed to have asthma

Table 5 Prevalence (percentage (numerator/denominator)) of reported precipitants of wheeze by age band

Age (years)	Cold	Non-cold precipitant	Exercise	Ingestant	Inhalant
0	81·8 (22/27)	33·3 (9/27)	3·7 (1/27)	14·8 (4/27)	7·4 (2/27)
1	94·1 (36/38)	30·6 (11/36)	8·8 (3/34)	8·6 (3/35)	5·0 (2/40)
2	88·4 (38/43)	40·0 (14/35)	35·9 (14/39)	8·6 (3/35)	21·4 (9/42)
3	83·3 (35/42)	30·2 (13/43)	33·3 (14/42)	7·7 (3/39)	20·0 (9/45)
>4	89·2 (58/65)	63·5 (33/52)	49·1 (28/57)	5·9 (3/51)	32·8 (21/64)
p Value	0·454	0·004	0·1110	0·762	0·005

(e is the base of natural logarithms). On the other hand a child of the same age who has 3 or more attacks per annum, who is always short of breath during attacks brought on by precipitants other than colds has an odds of $e^{(-3\cdot742+1\cdot286+1\cdot651+2\cdot298+2\cdot295)}=16\cdot25$, which is equivalent to a probability of 94% $(16\cdot25\div(1+16\cdot25)=0\cdot94)$ of having been diagnosed to have asthma.

Discussion

SEVERITY OF WHEEZE

Severity of wheeze was evaluated in this study on the basis of wheeze frequency and duration and the occurrence of associated breathing problems during and between attacks of wheeze. The results should be viewed as being no more than descriptive of what was actually observed. They should be interpreted with care because attained age and the accuracy of parental recall must necessarily influence the responses obtained. High repeatability of the question on wheeze provides some confidence that severity indices may also be accurate. Wheeze frequency has previously been shown to be a reliable indicator of the severity of wheezy illnesses.[4 9] In these studies patients were categorised arbitrarily by taking three or five attacks of wheeze as a cut off point between categories. This may have arisen from a tendency to define asthma in wheezy children only after three or more (sometimes five or more) episodes of wheeze.[18]

In this study the choices of numbers, that is, either frequency or duration, were similarly speculative and arbitrary and categories were based on previously used questionnaires.[11] As this study involved only preschool children, among whom it was presumed that parental recall would be more accurate and complete, the response subdivisions were less coarse and required more precise answers. This allowed for more detailed evaluation of severity. The age stratification of the study population afforded the opportunity to evaluate changes in severity criteria with age without complete confounding of duration of recall with age.

Nearly 20% of all wheezy children never experienced a second wheezing attack (within the time frame of follow up), a trend that was reasonably constant with age. The highest proportion of children in a single year band not experiencing a second attack was seen in the youngest age band. This might indicate that insufficient time had elapsed for further episodes to occur or that single episodes were not uncommon in this age band.

The distribution characteristics of wheezy episodes in the 12 months preceding the study mirrored that for the total number of wheezy episodes. A fifth of children had not had any wheezy episodes in the past year. The distribution of children in each year band for each category was remarkably similar.

Overall, shortness of breath during attacks affected two thirds of all wheezers. In two thirds of these it occurred occasionally and in the remaining one third with every episode. No age difference was present when comparing 'ever' with 'never' shortness of breath, but the prevalence of shortness of breath with every wheezy episode increased with age. A possible explanation for the age difference is that the more severe the wheezy illness the more likely it is to persist with age. Alternatively, parent perception of shortness of breath may vary with the age of the child affected.

No significant gender difference in severity was observed. In contrast, McNicol and Williams found that male asthmatics were more severely affected.[4] There were four times as many boys as girls in their most severe group, and more than twice as many in the second most severe group. The proportions were reversed in the mildest group with the predominance of girls. In this study the gender specific distributions were very similar for each of the five indices of severity. These findings are in agreement with those of Blair who showed that the sex of the child did not affect the severity at onset nor the ultimate prognosis.[19]

As in most other studies, the commonest precipitant in this study, affecting nearly 90% of wheezy children, was 'a cold', by implication viral infection of the upper respiratory tract.[18 21–24] Non-cold precipitants, and specifically exercise and airborne allergens were also fairly common, being responsible for attacks in about 40, 30, and 20% of children respectively. Many children reported more than one attack precipitant. Ingested allergens affected fewer than 10% of children. In their two cohorts of 12 year old children, Burr *et al* found that colds were the commonest wheeze precipitants, but that the frequency with which they precipitated wheezy episodes

Table 6 Indices of wheeze severity and reported precipitants and the probability that a wheezy child will be diagnosed as having asthma

Parameter	Coefficient	Odds ratio (95% confidence interval) relative to baseline category	Likelihood ratio test for the removal of variable
Intercept	−3·742	0·024 (0·005 to 0·113)*	
Age group (years)			χ^2_4=14·4, p=0·006
<1		1·00	
1–1·9	0·419	1·52 (0·45 to 5·15)	
2–2·9	0·185	1·20 (0·33 to 4·37)	
3–3·9	1·286	3·62 (1·06 to 12·40)	
>4	2·039	7·68 (2·04 to 28·93)	
Shortness of breath during attacks			χ^2_2=11·9, p=0·003
Never†		1·00	
Sometimes	1·284	3·61 (1·50 to 8·71)	
Always	1·651	5·21 (1·77 to 15·39)	
No of attacks during last year			χ^2_2=14·9, p=0·0006
None†		1·00	
1–2	1·805	6·08 (1·92 to 19·29)	
3+	2·298	9·95 (2·79 to 35·53)	
Precipitants other than colds			χ^2_1=9·0, p=0·0027
No†		1·00	
Yes	1·295	3·65 (1·54 to 8·63)	

*Estimated odds when all covariates at baseline. †Baseline group.

fell during the intervening 12 year period from 90% to 77%.[2 25] It was suggested that the increase in non-cold precipitants (running and animal exposure) relative to colds as wheeze precipitants reflected a true increase in asthma prevalence. The high rate of colds as precipitants of wheeze in this study is not in conflict with these observations. Further, when considering the prevalence of precipitants by age, non-cold precipitants and inhalants increased significantly (table 5). In the oldest year band half the children wheezed with exercise, the same proportion of children as in the latter survey of Burr *et al.*[2] One interpretation of these findings is that the wheeze at 5 years old is more likely to be due to asthma than wheeze at a year. However, colds remain an important precipitant of wheeze throughout the age range studied.

It was not possible to determine what proportion of wheezing attacks was triggered by colds or by non-cold precipitants. It could be argued that such data are important when assessing severity of wheeze and relation to asthma. However, the acquisition of such information from a population is necessarily limited by the method of data collection. For the information to be of use it must be reliable and reproducible. Both these factors are in turn reliant on the comprehensibility of the questions posed. It was felt that inquiry into the relative frequency with which different precipitants caused wheeze would be too complicated to answer simply (and therefore reliably) in the context of a postally administered, parentally completed questionnaire. The same limitations preclude separation of specific non-cold wheeze precipitants (exercise, inhalants, and ingestants) and diurnal variability into those that occur during recovery from a viral upper respiratory tract infection from these factors operating at other times.

Gender differences in the prevalences of precipitants have not been reported previously. The greater prevalence of exercise as a precipitant of wheeze in females, if confirmed, suggests that girls in this age group behave more like conventional asthmatics than boys.

Some 10% of wheezy episodes were precipitated by foods or fluids. This prevalence is similar to that reported in the questionnaire study of Burr *et al.*[2] Wilson found a prevalence of nearly 60% in white asthmatic children attending an asthma clinic.[10] In her study questionnaire findings were supplemented by a personal interview with each respondent. In the present study and that of Burr *et al* all children with wheeze were included rather than a selected group attending a hospital outpatient clinic for asthmatic children.[2]

Seasonal variation or more frequent symptoms at a particular time of year was present in about a third of children with wheeze, three quarters reporting a winter preponderance. This characteristic was more apparent in the older children. Diurnal variation of symptoms, particularly nocturnal worsening, is also a well known characteristic of asthma in older children and in adults. Nearly two thirds of wheezy preschool children in this study reported that symptoms were worse at a particular time in the day, mostly during the night. Population distribution was established early and remained constant with age. For seasonal and diurnal variations and also a family history of asthma there were strong associations with the diagnosis asthma on univariate analysis. This suggests that doctors diagnose asthma in preschool children when the severity and pattern of wheeze conform with the conventional textbook descriptions. Although this may seem self evident to doctors dealing with wheezy preschool children, we have been unable to find previous population based studies of randomly selected wheezy children in this age group that have focused on these characteristics of wheeze.

WHEEZE AND THE DIAGNOSIS OF ASTHMA

In preschool children age, wheeze severity, and precipitants other than colds were significantly associated with the diagnosis of asthma. Overall these findings probably reflect diagnostic criteria applied consciously or unconsciously by family doctors when considering whether wheezy preschool children have asthma. It is not intended to imply that all doctors apply these same criteria: some will undoubtedly be influenced by a family history of asthma and/or atopy. In the present study, however, it is clear that many wheezy children with family histories of these disorders were not diagnosed as having asthma. Whether the diagnosis of asthma was justified is uncertain as asthma in preschool children has never been clearly defined. The children studied were too young to have formal assessments of airway reactivity or reversibility to provide supportive evidence for this diagnosis. In this age group there is growing suspicion that many wheezy children do not have asthma,[20] at least by the criteria applied to older children and adults. However, the value of investigating which factors are important in arriving at a diagnosis of asthma in this age group becomes apparent upon realising that the chances of receiving appropriate treatment depend strongly upon the receipt of a formal diagnosis.[26] Indeed, the relationship between the outcome of appropriate treatment is very similar to the relationship between these same factors and the probability of receiving a formal doctor diagnosis of asthma. This will be the subject of a further report. The relevance of the present findings will only become clear when follow up studies, including physiological measurements, are conducted in this cohort of wheezy preschool children. Whether it is useful to classify as asthmatic a subgroup of wheezy preschool children will only be revealed in this way. The principal regression modelling reported in the results was based upon unconditional logistic regression and the binary response variable doctor diagnosed asthma (0=without, 1=with). However, it could be argued that older children who developed wheeze early in life are more likely to have been diagnosed as having asthma than younger children or those who developed wheeze later on, and that the inclusion of age group in the regression model would provide an incomplete adjustment for this effect. Indeed, one might argue that the ideal analysis would be a survival based (Cox regression) analysis using time since the development of wheeze as the primary time scale and doctor diagnosed asthma as the censoring variable. Unfortunately, it was considered probable that the reported ages of development of wheeze and diagnosis of asthma were likely to be considerably less reliable than the reports that wheeze either was or was not present and that asthma either had or had not been diagnosed. It was therefore considered unwise to adopt a survival based approach for the principal regression analysis. However, for the sake of completeness a Cox regression model was later constructed in the precisely same way as the original logistic regression model, and was found to contain the same predictor variables. Furthermore, inferences based upon the Cox model were very similar to those based upon the logistic regression model.

One might argue that the covariates in the regression model relate to symptoms at the time of questionnaire, but that interest should really have been directed at symptoms at the time of diagnosis of asthma. Unfortunately, these data were not available. Although this must inevitably have introduced some degree of approximation into the model it is our view that this approximation is unlikely to have greatly distorted the principal inferences based upon the model. If anything, given that one of the consequences of diagnosis is that treatment can be started and symptoms controlled, one might expect that if one did have access to the symptom profile at the time of diagnosis the apparent effect of the important covariates in the model might well have been greater than the apparent effects we report.

At a practical level, most doctors agree that episodes of wheeze accompanied by shortness of breath are characteristic of asthma at any age, but underdiagnosis is not precluded by this approach. Indeed, nearly one fifth of wheezers without the diagnosis of asthma in the present study had had more than six wheezy episodes, one quarter had had three or more wheezy episodes in the preceding year, and some 60% had had a wheezy episode within the preceding three months. If such children do indeed have asthma the underdiagnosis rate is approximately 25%.

Similarly, a significant number of children with shortness of breath during each attack of wheeziness had not been diagnosed as having asthma, the underdiagnosis rate being comparable with that described above for frequent wheezing episodes.

CONCLUSION

This study of the characteristics of wheeze in preschool children suggests that the distribution of severity in a young cohort is similar to that in older cohorts. There is no gender specific difference in wheeze severity despite the significantly greater prevalence of wheeze in boys than girls in this age group. Increasing wheeze frequency, shortness of breath during attacks, and non-cold precipitants of wheeze significantly increased the likelihood of asthma being diagnosed by a doctor. These findings suggest that doctors identify asthma appropriately (as judged from textbook descriptions) in some 75% of young children with wheeze, but there is no certainty that wheezers not diagnosed as having asthma will outgrow the tendency. Similarly, the natural history of those in whom asthma is diagnosed is uncertain. We are presently reassessing this cohort of children, now aged 5–7 years, to determine whether early symptoms and diagnoses made during the preschool period predict outcome in the early school age years.

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Dipstick test for malaria

In holoendemic rural areas of sub-Saharan Africa more than three quarters of children have continual *Plasmodium falciparum* parasitaemia. The demonstration of the parasite in blood is therefore unhelpful in the diagnosis of the cause of a febrile illness. An easy and rapid method of detecting parasitaemia would, however, be useful in urban areas and in other parts of the world.

In a study reported in the *Lancet* (Christine Beadle and colleagues, 1994; **343:** 564–8) a new dipstick test was compared with conventional blood films in adults and children in Kenya and in experimentally infected volunteers in America. The dipstick contains monoclonal antibodies against a water soluble antigen, *P falciparum* histidine-rich protein 2 (Pf H R P-2). Polyclonal antibodies to the same antigen conjugated to lipsomes containing a pink dye are used as the 'antigen detector reagent'. A single test can be done in 20 minutes and a batch of 10 tests takes 30 minutes. Sensitivity of the test depended on the degree of parasitaemia; it was 96·5 to 100% with 60 or more *P falciparum* asexual parasites per μl blood, 70–80% with between 11 and 60 parasites, and only 11–67% with 10 or fewer. Most patients with symptomatic falciparum malaria have more than 60 parasites per μl blood. Specificity of the dipstick test was 95% in American volunteers and 88% in Kenyans in a holoendemic area. The test was negative six days after starting treatment.

The authors provide no information about cost but suggest that the simplicity of the test could make it a useful tool.

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