Thorax 1981;**36**:842-846

Respiratory morbidity and lung function in schoolchildren aged 7 to 11 years in South Wales and the West of England

JWG YARNELL, AS ST LEGER

From the MRC Epidemiology Unit, Cardiff

ABSTRACT The present study tests the suggestion that the respiratory morbidity of children resident in South Wales is substantially higher than that among children resident in some other areas of the United Kingdom. A case control survey was carried out among 2228 children aged 7 to 11 years in schools matched for size and socioeconomic characteristics in urban and rural areas in South Wales and the West of England. The survey confirmed that respiratory morbidity was higher among children in South Wales and that this excess could not readily be dismissed as being caused by over-reporting. However, objective measurements of the children's respiratory health did not detect any consistent difference in the lung function of children in South Wales compared with that of children in the West of England.

A study[1] conducted in several centres in England and Wales suggested that respiratory morbidity was much higher among children in two areas in South Wales than that among children in England. The present study was carried out to test this observation and to examine possible reasons for and the significance of any such differences.

Methods

SCHOOLS

In order to test adequately the hypothesis that respiratory morbidity is higher in children from South Wales than in children from the West of England care was taken to ensure that the final sample selected was as representative as possible of children resident in both regions. Two comparable urban areas were chosen (Cardiff and Bristol). A wide rural area in the West of England (Avon) was selected for comparison with one rural and one semi-rural area in South Wales (Vale of Glamorgan and Merthyr Tydfil), since the latter areas were chosen to represent South Wales in the earlier study.[1] Four Cardiff schools were matched for size (total pupil numbers) and also by the use of a simple socioeconomic index (proportion of free school meals) with four schools in Merthyr Tydfil and with four schools in Bristol. Four schools in rural Avon were matched for population density (with the assistance of the 1971 Census County Reports), socioeconomic index, and size with five schools in the Vale of Glamorgan (two small schools in the Vale were matched with one in Avon). In total 21 schools were selected.

Address for reprint requests: Dr JWG Yarnell, MRC Epidemiology Unit, 4 Richmond Road, Cardiff CF2 3AS.

SUBJECTS

Almost all the schools had mixed ability classes. In such schools where the normal practice is to allocate pupils alternately by successive birthdays, one class was taken to be representative of one year's intake of children. In schools where "streaming" was practised representative samples were chosen from all the year's intake. In two large schools each with a small designated "special" class of low ability children from all age groups these classes were not considered for inclusion in the final sample. Where possible approximately 100 pupils were chosen from each school. The sizes of the schools ranged from 72 to 469 pupils (7-11 years only).

QUESTIONNAIRES

A questionnaire (copies of which may be obtained from the authors) was given to each parent or guardian of a child eligible for inclusion in the study. These questionnaires were distributed by the form teachers from each school. In addition to demographic and medical information the questionnaire included a number of standard questions derived from a Medical Research Council respiratory questionnaire suitable for use among children.[2] A precise history of each child's experience of "significant" respiratory tract infections was sought—this was defined as "an episode lasting three or more days and treated by a doctor". Both age at infection and total number of episodes were recorded. A "current" (previous 12 months) or previous history of asthma, hay fever, or eczema was noted.

CLINICAL MEASUREMENTS

Each child's height was recorded by the use of a Holtain stadiometer and the weight by the use of a beam balance by two trained observers. Measurements of lung function were made by the use of a McDermott dry spirometer by a single medical observer. The technique necessary to obtain the maximal respiratory values was demonstrated to small groups of children. Each child was allowed two practice attempts followed by three readings which were recorded. Forced expiratory volume (litres) in 0·75 second ($FEV_{0\cdot75}$) and forced vital capacity (litres) (FVC) were each recorded. The instrument temperature was recorded for each child. Barometric pressure, as recorded daily by the Meteorological Office at Rhoose Airport, was adjusted for altitude. The gas volumes for the respiratory values were standardised for temperature, adjusted barometric pressure, and water vapour pressure derived from the ambient temperature by use of Berry's equation.[3] Daily calibration of the spirometer was carried out during the course of the survey, which was carried out during the summer term of 1977. All schools were visited by appointment in haphazard order.

Absentees at the initial school visit were seen by the medical observer at a second visit. Portable measuring instruments for height and weight were used on these visits. A second questionnaire was sent to parents who had failed to return the questionnaire distributed by the school; 40 home visits were made to retrieve questionnaires not returned after a second letter had been sent.

STATISTICAL METHODS

Examination of the data shows that $FEV_{0\cdot75}$ and FVC are related to height and age. Height and age are themselves linearly related. The lung function indices were standardised to a height of 1300 mm, which also removed the effect of age.

The new indices were defined as follows:

$$FEV_{0\cdot75}\,I = \frac{FEV_{0\cdot75}}{Ht^{2\cdot503}} \times 1300^{2\cdot503}$$

$$FVC\,I = \frac{FVC}{Ht^{2\cdot762}} \times 1300^{2\cdot762}$$

The exponents (K) quoted above fit both males and females, and the new indices are in similar units to those of the raw $FEV_{0\cdot75}$ and FVC. The fit of Ht^K on $FEV_{0\cdot75}$ and FVC was tested in each area separately and overall. The fit was at least as good as the best simple linear model ($FEV_{0\cdot75} = a \times Ht + b$) within each area where a and b were estimated separately for each area and K was held constant over all areas. Asthmatic children were excluded when these exponents were estimated. The $FEV_{0\cdot75}$ I and FVC I are reasonably symmetrically distributed within each area and as is expected these distributions have smaller dispersions than those of unadjusted $FEV_{0\cdot75}$ and FVC.

The $FEV_{0\cdot75}$/FVC ratio is not entirely independent of height but the relationship is much weaker than for either $FEV_{0\cdot75}$ or FVC separately. (Note that before their use in these analyses both $FEV_{0\cdot75}$ and FVC were corrected for atmospheric pressure and temperature.)

Results

A total of 2305 children were eligible for inclusion in the study; 2228 (97%) children were seen at the schools and had the appropriate measurements made; 2132 (92%) parents completed the majority of each questionnaire. In approximately one-third of cases in which an incomplete questionnaire was returned this was because the child had been adopted.

Table 1 shows the distribution of certain indices of respiratory morbidity and of lung function by area. Lung function indices have been adjusted to a height of 1300 mm as described previously; non-Caucasian children have been excluded from the results of lung function because of known differences[4] in lung function in different ethnic groups. These differences were confirmed in the present study but respiratory morbidity was similar in different ethnic groups.

The prevalence of winter cough (persistent daily cough for three months or more in the winter) and of previous bronchitis or pneumonia (which lasted three or more days and was treated by a doctor) was similar in boys and girls but a higher prevalence of these indices was reported in the urban areas compared with the rural. In general the higher prevalences were reported from South Wales. Thus the mean prevalence of winter cough for both sexes was 29·5% compared with 20·9% for the West of England (Avon); the mean prevalence of previous bronchitis was 24·0% in South Wales compared with 14·9% for the West of England. The prevalence of asthma was reported to be higher in South Wales than in the West of England particularly in boys and the prevalence was higher in rural areas compared with urban. The prevalence of other atopy such as hay fever or eczema, showed no consistent variations

Table 1 *Respiratory morbidity and lung function in children resident in South Wales and in England*

History	*Merthyr Tydfil*		*Cardiff*		*Bristol*		*South Wales rural*		*Avon rural*	
Percent children with	*M* (*n* = 201)	*F* (*n* = 202)	*M* (*n* = 203)	*F* (*n* = 195)	*M* (*n* = 218)	*F* (*n* = 228)	*M* (*n* = 213)	*F* (*n* = 236)	*M* (*n* = 214)	*F* (*n* = 222)
Winter cough	32·8	33·2	33·0	33·9	27·1	25·0	24·9	19·2	17·3	14·1
Past history of bronchitis or pneumonia	32·4	30·1	23·8	20·6	15·6	12·2	21·5	15·3	17·5	14·2
Three or more episodes of bronchitis or pneumonia	13·7	10·3	9·4	9·2	6·3	4·8	10·5	5·5	8·8	4·4
Asthma in past 12 months	1·9	2·4	2·5	2·5	2·2	0·4	8·4	1·7	1·8	1·3
Any history of asthma	6·8	5·3	8·4	3·1	4·0	2·2	11·6	3·8	4·6	4·4
Hay fever in past 12 months	3·4	3·9	6·9	5·1	4·5	3·0	7·0	4·3	6·0	8·4
Previous hay fever or eczema	4·9	7·3	8·4	7·6	8·9	4·7	9·8	7·7	7·8	5·8
*$FEV_{0·75}$ Index (litres)	1·78	1·70	1·71	1·66	1·71	1·69	1·78	1·70	1·72	1·66
(SD)	(0·21)	(0·18)	(0·19)	(0·22)	(0·10)	(0·19)	(0·18)	(0·21)	(0·18)	(0·20)
*FVC Index (litres)	2·33	2·10	2·25	2·04	2·23	2·21	2·32	2·17	2·36	2·17
(SD)	(0·49)	(0·46)	(0·42)	(0·47)	(0·42)	(0·49)	(0·46)	(0·49)	(0·49)	(0·49)
*FEV/FVC %	86·7	90·7	86·4	89·3	86·4	89·8	85·6	89·6	87·1	89·5
(SD)	(6·6)	(6·0)	(6·7)	(6·8)	(7·2)	(6·0)	(7·8)	(6·3)	(6·6)	(6·2)

Caucasian children only.

Table 2 *Spearman rank correlation coefficients for male and female respiratory morbidity and lung function in 21 schools*

	Winter cough	*Bronchitis*	*Any history of asthma*	*$FEV_{0·75}$ index*	*FVC index*	*$\frac{FEV_{0·75}}{FVC}$*
Male versus female	0·74**	0·61**	−0·16	0·43	0·35	0·43

**$p < 0·01$.

between the areas.

The height standardised index $FEV_{0·75}$ I had higher values on average among children from South Wales but no consistent trends were apparent for FVC I. The mean values of the FEV/FVC ratio are 86·2% among Welsh boys compared with 86·8% among boys in the West of England. For girls the values were 89·9% and 89·7% respectively. Although lung function indices were generally lower in children from urban areas in South Wales compared with those from rural areas the reverse was true for children in the West of England.

The remaining tables examine the relationship between respiratory morbidity and lung function, and certain inter-relationships between indices of respiratory morbidity. The overall objective of these tabulations is to examine the possible causes of the uneven distribution of respiratory morbidity indices between South Wales and the West of England.

In table 2 indices were ranked by school separately for boys and girls; Spearman rank correlations have been calculated.

Winter cough and previous bronchitis were closely correlated in boys and girls but asthma did not show a close relationship between the sexes. Lung function indices show a weak positive correlation but the results are not statistically significant.

Table 3 shows data which examine the strength of the relationship between different indices of respiratory morbidity in each child and in their family members. Each cell represents the value of the χ^2 test of statistical association of positive respiratory symptoms or other indices of morbidity. In all cases a simple dichotomous relationship was used.

All but two associations examined (asthma against maternal and paternal phlegm) showed strongly positive associations. Although it is only possible to make crude comparisons between different cells a marked association between winter cough in children and productive cough in their

Table 3 *χ^2 values for associations between selected variables*

		Winter cough	*Bronchitis*	*Maternal phlegm*	*Paternal phlegm*
Bronchitis	M	87·8	—	—	—
	F	94·0	—	—	—
Maternal phlegm	M	132·2	17·7	—	—
	F	121·0	39·9	—	—
Paternal phlegm	M	69·6	17·7	136·9	—
	F	98·6	42·6	156·9	—
Sibling winter cough	M	163·6	11·0	136·6	85·6
	F	190·9	31·4	182·2	130·9
Any history of asthma	M	28·7	58·8	0·1	0·1
	F	19·5	48·8	6·5	0·4

$\chi^2 > 10·8$ (with 1 df $p < 0·001$).

Table 4 *Rank correlation coefficients between respiratory morbidity and school size*

		Winter cough	*Any history of asthma*	*$FEV_{0.75}$ index*	*$FEV_{0.75}$/ FVC*	*Sibling winter cough*
School size	M	0·25	−0·16	0·02	0·22	0·28
	F	0·36	0·35	−0·04	0·28	0·51*
Altitude	M	0·11	—	0·51*	−0·12	−0·04
	F	0·07	0·52*	0·27	0·16	0·06

*$p < 0·05$.

mothers and siblings is shown. By contrast, with previous history of bronchitis the most marked association is with asthma (rather than with symptoms in mothers and siblings).

Table 4 shows the relationship between school size, altitude, and certain indices of respiratory morbidity. Within these rank correlations the number of paired observations (several schools were of the same size or at the same altitude) has been taken into consideration.

Only winter cough, $FEV_{0·75}$/FVC ratio and sibling winter cough showed a consistent (but slight) correlation with the size of the schools (the largest schools were ranked highest). Altitude showed a positive correlation with $FEV_{0·75}$ I (the schools situated at the greatest altitude were ranked highest).

Discussion

These results confirm the finding that respiratory morbidity among children reported by parents was higher among children in South Wales than that reported among a comparable sample of children in the West of England. However, tests of lung function did not detect any significant differences in the respiratory health of children in South Wales compared with that of children from the West of England.

Within schools the prevalence of winter cough in males was closely correlated with that in females (table 2). The same was true for previous bronchitis but not for asthma. Winter cough and previous bronchitis were associated with each other and also with symptoms reported in other family members (parents and siblings) (table 3). Such a familial tendency may be consistent with constitutional or environmental causes or a combination of both. The data may also be consistent with over-reporting of symptoms in children by parents who themselves have symptoms; and a recent study[5] suggested that patients of all ages in South Wales tended to consult doctors more commonly than was the case among patients from the West of England. But our definition of previous bronchitis was fairly precise (lasting three or more days and treated by a doctor) and should not be subject to reporting biases. Asthma is known to have a strong constitutional or inherited component,[6] and the present data indicate a relationship between asthma and winter cough and previous bronchitis; but there is no evidence of an association between asthma and parental symptoms (table 3). The major cause of productive cough in adults is cigarette smoking,[7 8] and a marked association between parental phlegm and household cigarette smoking was confirmed in the present data. In this sample household smoking tended to be more common in Welsh families than among those from Avon (62% and 54% respectively). Similarly 43% of women from South Wales reported that they had smoked during pregnancy compard to 36% from Avon. Smoking habit and other environmental factors such as higher annual rainfall may provide a partial explanation for the higher respiratory morbidity in South Wales.

Atmospheric pollution before the 1956 and 1968 Clean Air Acts was known to influence both respiratory morbidity[9] and lung function[10] in children. Data[11] from the available monitoring sites in South Wales and Avon provide no support for the view that atmospheric pollution is an important factor in explaining variation in respiratory morbidity. Other data[12] from this study indicate that only current asthma or multiple episodes of bronchitis significantly reduce the lung function of individual children. The proportion of children in these categories is small in both South Wales and the West of England, but parents in Merthyr Tydfil and Cardiff reported a higher proportion of children with three or more episodes of bronchitis than was the case elsewhere (table 1). Examination of the same data showed some differences in the $FEV_{0·75}$ and FVC indices in different areas when the effects of the other variables were held constant. These were not consistent between the areas however and any differences between the areas with respect to the $FEV_{0·75}$/FVC ratio were both small and inconsistent. It seems reasonable to conclude therefore that, although the increased respiratory morbidity in these Welsh children is apparently real, its effect on the respiratory health of the majority of children from South Wales is likely to be trivial.

We thank Drs Marie Freeman, Deirdre Hine and Alan Davies for their help in this study, Mrs Janie Hughes and Mrs Marion Jones for their meticulous fieldwork.

References

1 Colley JRT, Reid DD. Urban and social origins of childhood bronchitis in England and Wales. *Br Med J* 1970;**2**:213-7.

2 Medical Research Council. *Respiratory symptoms.* London: Medical Research Council, 1976.
3 Berry G. Terminology. In: Cotes JE, ed. *Lung function.* Third edition. Oxford: Blackwell, 1975:20.
4 Miller GJ, Saunders MJ, Gilson RJC, Ashcroft MT. Lung function of healthy boys and girls in Jamaica in relation to ethnic composition, test exercise performance, and habitual physical acitvity. *Thorax* 1977;**32**:486-96.
5 Jones DA, Sweetnam PM, Elwood PC. Drug prescribing in Wales and England. *J Epidem Comm Hlth* 1980;**34**:119-23.
6 Emery AEU. *Methodology in medical genetics.* Edinburgh: Churchill Livingstone, 1976:54.
7 Leeder SR, Corkhill R, Irwig LM, Holland WW, Colley JRT. Influence of family factors on the incidence of lower respiratory illness during the first year of life. *Br J Prev Soc Med* 1976;**30**:203-12.
8 Colley JRT, Douglas JWB, Reid DD. Respiratory disease in young adults: influence of early childhood lower respiratory tract illness, social class, air pollution and smoking. *Br Med J* 1973;**3**:195-8.
9 Douglas JWB, Waller RE. Air pollution and respiratory infection in children. *Br J Prev Soc Med* 1966;**20**:1-8.
10 Lunn JE, Knowelden J, Handyside AJ. Patterns of respiratory illness in Sheffield infant schoolchildren. *Br J Prev Soc Med* 1967;**21**:7-16.
11 Warren Spring Laboratory. National survey of smoke and sulphur dioxide April 1976-March 1977. London: Department of Industry and Trade, 1978.
12 Yarnell JWG, St Leger AS. Respiratory infections and their influence on lung function in children: a multiple regression analysis. *Thorax* 1981;**36**:847-51.