Thorax 1987;**42**:542–548

Ethnic variation in respiratory morbidity and lung function in childhood

I D A JOHNSTON, J M BLAND, H R ANDERSON

From the Department of Clinical Epidemiology and Social Medicine, St George's Hospital Medical School, London, and University Hospital, Nottingham

ABSTRACT In a population of 5689 primary schoolchildren there were few important differences between children of European (n = 5287), African (n = 198), and Indian origin (n = 204) in the prevalence of a history of past respiratory illnesses or current respiratory symptoms. The reported 12 month period prevalence of the symptom "ever wheezy" was 15%, 18%, and 17% respectively in the three ethnic groups (differences not significant). In a subsample of 973 European, 47 African, and 40 Indian children forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were significantly lower by 12% and 13% in Africans and by 8% and 9% in Indians than in Europeans after adjustment to the group mean height of 128 cm. No significant ethnic variation was found for forced mid expiratory flow, FEV_1/FVC, or mean transit time. Since the lung function studies were performed on a sample from a large population with little variation in respiratory mobidity, the differences are likely to reflect human biological differences. Separate prediction equations need to be developed for the different ethnic groups in childhood.

Introduction

Although it has been known for many years that there are ethnic differences in lung function,[1] most comparisons between ethnic groups in childhood have been made between children of European and African origins in the United States[2-8] or Jamaica.[9] Despite the substantial size of the non-European ethnic groups in Britain there has been very little study of ethnic variation in lung function in this country[10 32] and only one published statistical analysis comparing the lung function in European, African, and Indian children in the same population either in Britain or elsewhere.

Even less is known about the comparative respiratory morbidity in European, African, and Indian children. Such information would throw light on the relative roles of constitutional and environmental factors in the aetiology of respiratory disease in children. The few data that are available suggest that wheezing illness may be more common in African children born in Britain than in Europeans.[11 12] Adults of African origin have been shown to have a lower prevalence of chronic bronchitis than Europeans (in the United States)[13] and Indians (in Guyana).[14]

We report the prevalence of respiratory symptoms and lung function findings in a large ethnically mixed population of South London primary school children.

Address for correspondence: Dr I D A Johnston, D Floor, South Block, University Hospital, Nottingham NG7 2UH. (Reprints will not be available.)

Accepted 9 December 1986

Methods

The data were obtained during a study designed primarily to investigate the effects of whooping cough on subsequent respiratory morbidity and lung function in primary schoolchildren.[15] In this study we sent a respiratory questionnaire to the parents of all children in the same school class as those children we had previously identified as having had whooping cough. Replies were received from 80% of 7337 parents. The questionnaire obtained data about previous respiratory illnesses and current (last 12 months) respiratory symptoms and about hospital admissions, breast feeding history, family size, parental occupation, parental smoking, and family history of wheezing illness. All children whose parents had been sent the respiratory questionnaire were classified by appearance into those of "European," "African," and "Indian" descent and "others" (including those of mixed race). In our study area, 70% of children of "African" descent were from families who had emigrated from the

Caribbean and 84% of children of "Indian" descent were from the Indian subcontinent. The ethnic group of children absent from school was determined by inquiry from both the class teacher and the school nurse. The three main ethnic groups, European, African, and Indian, were compared with respect to the data obtained from the respiratory questionnaire.

Subsequently a sample of 1071 children was selected for lung function testing at school. The methods of selection have been described in detail elsewhere.[15] In brief, 360 children with a history of whooping cough were selected. For each of these, two school class controls with no previous whooping cough, matched for sex but not ethnicity, were randomly selected from parental responses to the respiratory questionnaire (total 711, only one control being available for nine of the cases). The lung function sample was compared with the remainder of the population from which it was drawn with respect to the respiratory questionnaire data to assess representativeness.

Physical examination and lung function testing was performed by a single observer (IDAJ). No child was excluded (for example, because of respiratory infection) provided that he or she was attending school on the study day. Weight was measured to 0·1 kg with portable field survey scales (CMS Weighing Equipment Ltd) and height to 0·001 m with a portable stadiometer (Holtain Ltd). Skinfold thicknesses at four sites (biceps, triceps, subscapular, and anterior superior iliac spine) were measured on the left side to 0·1 mm (Harpenden Skinfold Calipers), together with arm circumference to 1 mm. The chest was examined and the presence of upper respiratory tract infection noted.

Lung function testing was performed with an S-model spirometer (Vitalograph Ltd), in the standing position for younger children and the sitting position for older children. Noseclips were not routinely worn. After at least two practice attempts, three satisfactory blows were recorded. Provided that the lung function record met standard criteria for acceptance,[16] the highest values for the forced expiratory volume in 0·75 second ($FEV_{0·75}$) and 1 second (FEV_1) and forced vital capacity (FVC) were selected for analysis. The forced expiratory ratio $FEV_1/FVC \times 100$ (FEV%) was determined, and the forced expiratory flow between 25% and 75% of the FVC (FEF) was estimated from the curve with the largest FEV_1 and FVC by means of plastic overlay. A microprocessor (Function Analyser, Vitalograph Ltd) provided a printout of mean transit time (MTT). All volumes were converted to body temperature and pressure.[1]

Skinfold thicknesses were transformed to a logarithmic scale by means of an equation: skinfold transform (ST) = $100 \times \log_{10}$ (reading in 0·1 mm−18).[17] Fat free mass (FFM) was derived from the skinfold measurements on the basis of published equations.[18] Stepwise regression of the lung function indices on age and all anthropometric variables showed that by far the most important independent variable for $FEV_{0·75}$, FEV_1, FVC, and FEF was height, which was then used alone in subsequent analysis. A linear model was chosen since it accounted for a higher proportion of the variance of $FEV_{0·75}$, FEV_1, FVC, and FEF than various logarithmic models. Analysis of covariance was then performed to determine the effects of ethnicity. χ^2 tests were used for comparisons of categorical variables and t tests were used for continuous variables.

All relevant ethical committees approved the study and all parents gave signed consent to the examination of their child.

Results

Replies to the respiratory questionnaire were received from the parents of 5287 European, 198 African, and 204 Indian children, response rates of 80%, 60%, and 63% respectively. One hundred and seventeen replies

Table 1 *Background data (% n) on the children in the samples*

	Whole sample			*Lung function sample*		
	European (n = 5287)	*African (n = 198)*	*Indian (n = 204)*	*European (n = 973)*	*African (n = 47)*	*Indian (n = 40)*
†Manual social class***	50	58	29	53	44	41
Parental smoking***	59	44	39	63	47	40
Breast fed***	41	68	56	38	68	65
Siblings aged < 5 y	31	34	29	30	47	30
5–14 y	68	64	65	69	64	68
Hospital admission ever	39	35	33	43	28	38
Family history of asthma	14	11	9	16	2	13
Family history of wheeze*	19	15	12	21	2	3

†Percentages of those for whom data were recorded.
*p < 0·05; ***p < 0·001 (significant differences between ethnic groups found only within whole sample).

Table 2 *History of past chest illnesses (% n)*

	Whole sample			*Lung function sample*		
	European (n = 5287)	*African (n = 198)*	*Indian (n = 204)*	*European (n = 973)*	*African (n = 47)*	*Indian (n = 40)*
Croup***	12	3	2	12	6	3
Pneumonia	3	3	1	5	6	0
Whooping cough***	19	12	9	35	32	10
Bronchitis*	9	6	4	11	9	10
Wheezy bronchitis	9	7	6	11	4	8
Wheeze	11	13	9	11	15	15
Asthma	5	7	3	5	9	3
Wheezy bronchitis or wheeze or asthma	17	20	13	18	21	18

*p < 0·05; ***p < 0·001 (significant differences between ethnic groups only found within whole sample).

Table 3 *Respiratory symptoms in the previous 12 months (% n)*

	Whole sample			*Lung function sample*		
	European (n = 5287)	*African (n = 198)*	*Indian (n = 204)*	*European (n = 973)*	*African (n = 47)*	*Indian (n = 40)*
Morning cough	8	12	9	9	13	3
Day or night cough**	16	25	15	16	32	8
Morning phlegm	3	5	4	4	4	3
Day or night phlegm	4	5	5	6	2	3
Chest ever wheezy	15	18	17	16	21	18
More breathless than others***	8	11	13	8	11	13
Cough or cold in previous two weeks	33	40	35	35	36	28

**p < 0·01; ***p < 0·001 (significant differences between ethnic groups only found within whole sample).

were received from parents of other or mixed ethnic groups and these were not analysed further. Fifty per cent of the children were boys. Twenty nine per cent were aged 5–6 years, 41% 7–8 years, 21% 9–10 years, and 9% 11–13 years. There were no significant differences in the sex or age distribution between the three ethnic groups. There were, however, significant differences in the distribution of social class, parental smoking, history of breast feeding (all $p < 0·001$), and a family history of wheezing illness ($p < 0·05$) (table 1). No differences were found in the proportions of children with siblings aged under five or 5–15 years. Significantly more European children had had croup, whooping cough, and bronchitis but no significant differences were found in the history of wheezing illness (table 2). The distribution of current respiratory symptoms showed significant differences only for day or night cough and whether the child was more breathless on running than others (table 3). In particular the 12 months period prevalence of wheeze was very similar in the three groups at 15% for Europeans, 18% for Africans, and 17% for Indians.

Of the lung function sample, 973 were European, 47 African, and 40 Indian and the proportion of boys was 44%, 55%, and 55%. Twenty six per cent of the sample were aged 5–6 years (26%, 32% and 23% for European, African, and Indian children); 47% 7–8 years (48%, 45%, 40%); 18% 9–10 years (18%, 13%,

Table 4 *Mean age and anthropometric data adjusted for sex (lung function sample)*

	European (n = 973)	*African (n = 47)*	*Indian (n = 40)*	*p**
Age (y)	7·8	7·5	8·1	0·2
Height (cm)	128·1	128·6	128·7	0·9
Weight (kg)	26·8	26·9	27·3	0·9
Biceps ST	163·4	151·4	166·5	0·001
Triceps ST	194·3	185·1	197·7	<0·001
Subscapular ST	161·2	158·2	171·7	0·003
Asis ST	169·1	158·9	182·7	<0·001
Arm circumference (cm)	19·4	19·4	19·3	0·9
Fat free mass (kg)	21·3	21·8	21·1	0·8

*Analysis of variance.
ST—skinfold transform; Asis—anterior superior iliac spine.

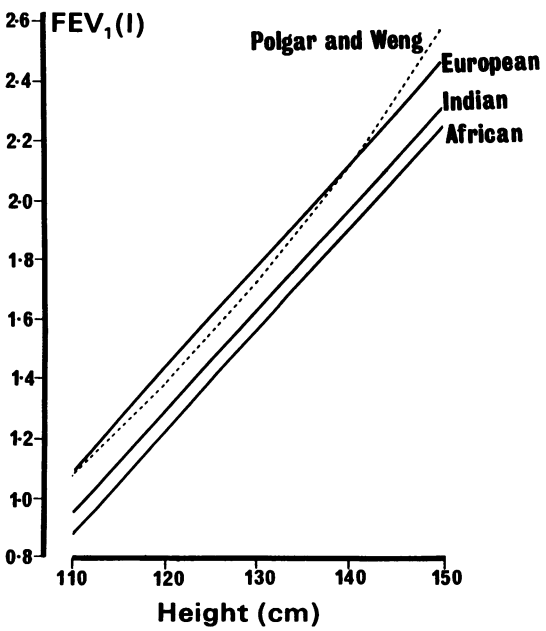
Table 5 *Mean lung function adjusted to height 128 cm and 95% confidence intervals of differences between ethnic groups*

	European (n)	*African (n)*	*Indian (n)*	*SD*	*European-African*	*European-Indian*	*Indian-African*
$EV_{0.75}$:							
M	1·61 (423)	1·41 (25)	1·48 (22)	0·19	0·20* (0·06 to 0·34)	0·13* (0·04 to 0·21)	0·07 (−0·04 to 0·18)
F	1·55 (544)	1·38 (20)	1·47 (18)	0·16	0·17* (0·04 to 0·30)	0·08* (0·01 to 0·16)	0·09 (−0·02 to 0·19)
All	1·58 (967)	1·40 (45)	1·48 (40)	0·18	0·18* (0·08 to 0·27)	0·10* (0·04 to 0·16)	0·08* (0·01 to 0·16)
$EV_{1.0}$							
M	1·74 (417)	1·51 (25)	1·57 (21)	0·21	0·23* (0·09 to 0·38)	0·17* (0·08 to 0·26)	0·06 (−0·06 to 0·18)
F	1·67 (539)	1·47 (19)	1·56 (18)	0·17	0·20* (0·06 to 0·34)	0·11* (0·03 to 0·19)	0·09 (−0·02 to 0·20)
All	1·70 (956)	1·49 (44)	1·56 (39)	0·18	0·21* (0·11 to 0·31)	0·14* (0·08 to 0·20)	0·07 (−0·01 to 0·15)
VC†:							
M	1·99 (401)	1·70 (24)	1·77 (21)	0·21	0·28* (0·13 to 0·44)	0·22* (0·13 to 0·31)	0·06 (−0·06 to 0·19)
F	1·86 (509)	1·62 (19)	1·71 (18)	0·18	0·23* (0·08 to 0·38)	0·15* (0·06 to 0·24)	0·08 (−0·04 to 0·20)
All	1·92 (910)	1·67 (43)	1·74 (39)	0·21	0·25* (0·13 to 0·36)	0·18* (0·11 to 0·25)	0·07 (−0·02 to 0·16)
EF:							
M	2·09 (401)	1·96 (24)	2·14 (19)	0·52	0·13 (−0·26 to 0·52)	−0·06 (−0·30 to 0·18)	0·18 (−0·13 to 0·50)
F	2·17 (507)	1·99 (19)	2·21 (18)	0·47	0·18 (−0·20 to 0·55)	−0·04 (−0·26 to 0·18)	0·22 (−0·08 to 0·52)
All	2·13 (908)	1·98 (43)	2·17 (37)	0·49	0·15 (−0·12 to 0·42)	−0·05 (−0·21 to 0·11)	0·20 (−0·02 to 0·41)

†Interaction between ethnicity and height; differences and confidence intervals relevant for height of 128 cm only.
*$p < 0·05$ (analysis of covariance).

20%); and 9% 11–13 years (9%, 11%, 17%). The ethnic differences in age distribution were not significant. The pattern of respiratory symptoms and illnesses among the lung function sample closely resembled that of the remainder of the population from which it was drawn. In the lung function group the proportion of European and African children (though not Indian) who had had whooping cough was higher, as would be expected from the selection procedure, and the proportion of African and Indian children with a family history of wheezing illness was significantly lower. Within the lung function sample a history of either wheezy bronchitis, wheeze, or asthma at some time was reported in very similar proportions of the ethnic groups (table 2).

The mean age, height, weight, arm circumference, and FFM (table 4) did not differ significantly between ethnic groups, but the effect of ethnicity was significant for all skinfold transforms (Indian children > European > African). On auscultation wheeze was found in 7% of European, 9% of African, and 10% of Indian children. The mean values of the height dependent variables $FEV_{0.75}$, FEV_1, FVC, and FEF for each ethnic group were adjusted to the overall mean height of the subjects, 128 cm. At this height, $FEV_{0.75}$, FEV_1, and FVC were significantly lower in African children (by 11%, 12%, and 13%) and in Indian children (by 6%, 8%, and 9%) than in European children (table 5). These differences were similar and still significant for boys and girls separately, with consistently slightly larger differences found for boys. For FVC there was a significant interaction of ethnic group with height in that the regression lines for European and Indian children diverged significantly with increasing height, but in view of the relatively small numbers in the non-European groups we have for simplicity presented the data as though there were no interaction. African children had lower $FEV_{0.75}$, FEV_1, and FVC than Indian children, by 5%, 4%, and 4%; but these differences were not significant except for $FEV_{0.75}$ No significant differences were found in FEF between ethnic groups, though Indians, both boys and girls, had higher mean values than Europeans and Africans had the lowest values. The regression lines from anal-



FEV_1 in the three ethnic groups (regression lines derived from analysis of covariance) with summary curve of Polgar and Weng[18] for comparison.

Table 6 *Mean (SD) forced expiratory ratios (FEV%) and mean transit times (MTT)*

	European			*African*			*Indian*		
	Mean	*(n)*	*SD*	*Mean*	*(n)*	*SD*	*Mean*	*(n)*	*SD*
FEV (%)									
M	87·7	(401)	5·3	89·4	(24)	3·7	89·2	(21)	5·8
F	90·1	(509)	4·8	90·6	(19)	4·1	91·3	(18)	3·0
All	89·0	(910)	5·1	89·9	(43)	3·9	90·3	(39)	4·8
MTT (s)									
M	0·49	(290)	0·11	0·46	(12)	0·09	0·49	(13)	0·13
F	0·45	(327)	0·10	0·45	(10)	0·08	0·41	(11)	0·08
All	0·47	(617)	0·11	0·45	(22)	0·08	0·46	(24)	0·12

No differences significant.

ysis of covariance for FEV_1 for each group over the range 110–150 cm, which included 95% of the subjects, are shown graphically (figure), with the summary curve from Polgar and Weng.[19] Both African and Indian children had a slightly higher mean FEV% and lower MTT than European children, but the differences were not significant (table 6).

Analysis of the effect of respiratory illnesses and symptoms on lung function in the group as a whole showed that a past history of pneumonia or wheezing illness and a current history of wheeze or breathlessness were highly significantly associated with FEV_1 and FEF. A past history of wheezing illness was, however, associated with an increase in FVC. We have previously shown that a history of whooping cough has no effect on lung function in children in general[15]; further analyses for the purposes of the present study showed no significant effect of whooping cough on any index of lung function in any ethnic group.

Discussion

The question of whether there is ethnic variation in the experience of respiratory illnesses and symptoms is important both clinically, since children of non-European origin comprised over 11% of our population, and epidemiologically, since the relative contributions of constitutional and environmental factors to respiratory disease are not clearly established. Neither is it known whether differing respiratory morbidity is reflected in differing lung function or vice versa. We therefore took the opportunity to study both respiratory morbidity and lung function in different ethnic groups within the same population.

In this study current respiratory symptoms were least common in European children, though significant differences were found only for cough during the day or night and breathlessness, which were commonest in African and Indian children respectively. Past croup, whooping cough, and bronchitis were reported more commonly in European children. All respiratory symptoms and past illnesses (with the exception of current breathlessness) were consistently reported as commonly or more commonly in Africans than in Indians, though most of these differences were small and non-significant.

In view of our sampling methods the study cannot be considered to be a true prevalence survey. Nevertheless, our symptom prevalence rates are similar to those found in the few previous studies in which comparable questions have been asked. The 16% prevalence rate for chronic cough in our study is similar to that in certain earlier studies[20 21] and, while the 12 month prevalence of wheeze (15%) is somewhat higher than the 11% recorded over one to two years by others,[22 23] these latter studies inquired about episodes or attacks of wheeze rather than whether the chest was ever wheezy. Our lifetime prevalence of wheezing illness (17%) compares with that of 18% from the study of McNicol and Williams.[24]

Despite the possibility that sampling methods make interpretation of the absolute prevalence rates more difficult, internal comparisons within the population—namely, between ethnic groups—are valid. Several other factors, however, may have influenced such comparisons. Firstly, the response rate was slightly lower in both the non-European groups and, because we were unable to evaluate non-responders, this might have introduced bias. Secondly, whooping cough was more common in Europeans and we have previously reported this disease to be associated with increased respiratory morbidity.[15] The excess of whooping cough is not, however, large enough to have had a material effect on the comparison of symptom prevalence in the present study. Thirdly, we do not know how cultural factors influence the understanding of and response to the respiratory questionnaire. Fourthly, there were significant differences between ethnic groups in social class, parental smoking, and family history of wheezing illnesses, all factors known to influence respiratory morbidity,[20 21 25] and in breast feeding, for which the evidence is conflicting.[26] With the exception of the lower social class of the African children, however, all these factors would be expected to have reduced respiratory morbidity in the non-European groups. Finally, country of birth is an important possible confounding factor. A lower prevalence of asthma and wheeze has been found in non-European

children born abroad[11] and childhood asthma is uncommon in rural areas of Nigeria and Gambia[27 28] and India,[29] though more recently an 8% prevalence of asthma has been found in children in rural Tanzania.[30] We do not know the country of birth of our children but, at the time of the study, only 3% of all children aged 5–15 years in our study area with parents of West Indian origin and 32% of those with parents of Indian origin had been born abroad.[31] Since the figures are even smaller for younger children and 90% of our sample were aged 10 years or younger, the great majority of our sample is likely to have been born in Britain. We conclude, then, that in this population of nearly 5700 London primary schoolchildren there was little variation in respiratory morbidity between ethnic groups.

Ventilatory capacity was significantly lower in African and Indian children than in Europeans. African children had lower values than Indian children but the differences were significant only for $FEV_{0.75}$. Similar differences were found for boys and girls separately. No significant ethnic differences were found in the derived indices FEF, FEV%, or MTT. Although the methods of selection had the result that one third of the lung function subjects had had whooping cough, we have previously shown that this disease has no effect on subsequent lung function,[15] and the present study confirms this for the different ethnic groups separately. We have not derived prediction equations in view of the methods of selection and the small numbers of non-Europeans; but comparisons between ethnic groups are valid and unlikely to be affected by selection bias or technical factors, since all measurements were made by a single observer and coefficients of variation of the spirometric indices compare well with the results of previous studies of childhood lung function.[1 19] Furthermore, the regression lines for Europeans for the height dependent variables are close to the summary lines of Polgar and Weng.[19] The data on mean transit time, should, however, be interpreted cautiously, as the measurement of MTT with the function analyser has not been formally validated.

In two previous studies comparing the three ethnic groups ventilatory capacity in childhood was also considerably lower in Indian and African children,[10 32] but only one of these studies[32] presented any statistical comparison and neither reported comparisons of respiratory morbidity. Comparisons of African and European children alone have revealed differences in forced expiratory volumes of a similar magnitude to those in our own data,[2–9] with a trend to lower flow rates in Africans[6 8 9] and little difference in FEV%,[7] though few studies provide statistical comparisons.[8] European and Indian children have not previously been compared, but Indian children in India have a VC about 15% lower than that predicted for Europeans.[33] In adults differences between Europeans and Africans in forced expiratory volumes similar to those in children have been documented,[34–36] Indians having lower values than Africans.[37 38] Comparisons of Indian and European adults in different populations have shown lower forced volumes but similar or higher FEV% in Indians,[39–42] though the differences are highly dependent on geographical area and altitude.[42]

Since the lung function group was sampled from a larger population with little variation in respiratory morbidity, the observed differences are unlikely to be explained by differences in respiratory morbidity. Furthermore, our lung function data for Africans and Europeans are in broad agreement with those from studies performed on subjects with no evidence of past or present respiratory disease.[4 6 8] The differences found are thus likely to be biological in origin. It has been suggested that the fact that Africans have smaller lung volumes than Europeans at the same standing height is due to the smaller ratio of sitting height to standing height in Africans. If this is so, the use of sitting height might allow single prediction equations to be developed that apply to all three ethnic groups.[43] This is unlikely, however, since others have found that substantial African-European differences in ventilatory capacity remain even when sitting height is used[2 9] and that sitting height is no better a predictor of FVC than standing height.[44] Furthermore, the ratio of sitting height to standing height is similar for Indians and Europeans (JE Cotes, personal communication). Finally, though it may be appropriate in adults to obtain prediction values for other ethnic groups by applying a constant scaling factor to European values,[36] our findings confirm that this practice may not be valid in childhood.[4 5 43] We suggest that further study is required to develop separate prediction equations for the different ethnic groups in childhood.

We thank the Department of Health and Social Security for funding the study, and Mr A Tickle for statistical assistance and Drs JE Cotes and JM Patrick for helpful comments. A copy of the questionnaire used in this study has been lodged with the editor and additional copies may be obtained from the authors on request.

References

1 Cotes JE. *Lung function: assessment and application in medicine*. 4th ed. Oxford: Blackwell Scientific Publications, 1979.
2 Smillie WG, Augustine DL. Vital capacity of Negro race. *JAMA* 1926;**87**:2055–8.
3 Chehreh MN, Young RC, Viaene H, Ross CW, Scott RB. Spirometric standards for healthy inner-city black children. *Am J Dis Child* 1973;**126**:159–63.
4 Binder RE, Mitchell CA, Schoenberg JB, Bouhuys A. Lung function among black and white children. *Am Rev Respir Dis* 1976;**114**:955–9.

5 Schoenberg JB, Beck GJ, Bouhuys A. Growth and decay of pulmonary function in healthy blacks and whites. *Respir Physiol* 1978;**33**:367–93.
6 Hsu KHK, Jenkins DE, Hsi BP, Bourhofer E, Thompson V, Tanakawa N, Hsieh GSJ. Ventilatory functions of normal children and young adults: Mexican-American, white and black. I. Spirometry. *J Pediatr* 1979;**95**:14–23.
7 Dockery DW, Berkey CS, Ware JH, Speizer FE, Ferris BG. Distribution of forced vital capacity and forced expiratory volume in one second in children six to 11 years of age. *Am Rev Respir Dis* 1983;**128**:405–12.
8 Strope GL, Helms RW. A longitudinal study of spirometry in young black and young white children. *Am Rev Respir Dis* 1984;**130**:1100–7.
9 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 activity. *Thorax* 1977; **32**:486–96.
10 Yarnell JWG, St Leger AS. Respiratory infections and their influence on lung function in children: a multiple regression analysis. *Thorax* 1981;**36**:847–51.
11 Morrison Smith J. The prevalence of asthma and wheezing in children. *Br J Dis Chest* 1976;**70**:73–7.
12 Spears J. The prevalence of allergic disease in young British-born school children of different ethnic origin. *J R Coll Gen Pract* 1975;**25**:282–5.
13 Massaro D, Cusick A, Katz S. Racial differences in incidence of chronic bronchitis. *Am Rev Respir Dis* 1965; **92**:94–101.
14 Miller GJ, Ashcroft MT. A community survey of respiratory disease among East Indian and African adults in Guyana. *Thorax* 1971;**26**:331–8.
15 Johnston IDA, Anderson HR, Lambert HP, Patel S. Respiratory morbidity and lung function after whooping cough. *Lancet* 1983;ii:1104–8.
16 American Thoracic Society. ATS Statement—Snowbird Workshop on standardisation of spirometry. *Am Rev Respir Dis* 1979;**119**:831–8.
17 Tanner JM, Whitehouse RH. Revised standards for triceps and subscapular skinfolds in British children. *Arch Dis Child* 1975;**50**:142–5.
18 Durnin JVGA, Rahaman MM. The assessment of the amount of fat in the human body from measurements of skinfold thickness. *Br J Nutr* 1967;**21**:681–9.
19 Polgar G, Weng TR. The functional development of the respiratory system. *Am Rev Respir Dis* 1979;**120**: 625–95.
20 Colley JRT, Reid DD. Urban and social origins of childhood bronchitis in England and Wales. *Br Med J* 1970;ii:213–7.
21 Colley JRT. Respiratory symptoms in children and parental smoking and phlegm production. *Br Med J* 1974;ii:201–4.
22 Anderson HR, Bailey P, Cooper JS, Palmer JC. Influence of morbidity, illness label, and social, family, and health service factors on drug treatment of childhood asthma. *Lancet* 1981;ii:1030–2.
23 Lee DA, Winslow NR, Speight ANP, Hey AN. Prevalence and spectrum of asthma in childhood. *Br Med J* 1983;**286**:1256–8.
24 McNicol KN, Williams HE. Spectrum of asthma in children—I. Clinical and physiological components. *Br Med J* 1973;iv:7–11.
25 Schenker MB, Samet JM, Speizer FE. Risk factors for childhood respiratory disease. *Am Rev Respir Dis* 1983;**128**:1038–43.
26 Burr ML. Does infant feeding affect the risk of allergy? *Arch Dis Child* 1983;**58**:561–5.
27 Warrell DA, Fawcett IW, Harrison BDW, *et al.* Bronchial asthma in the Nigerian savanna region. *Q J Med* 1975;**44**:325–47.
28 Godfrey RC. Asthma and IgE levels in rural and urban communities of the Gambia. *Clin Allergy* 1975;**5**: 201–7.
29 Viswanathan R. The problem of asthma. *Indian J Chest Dis* 1972;**14**:277–89.
30 Carswell F, Merrett J, Merrett TG, Meakins RH, Harland PSEG. IgE, parasites and asthma in Tanzanian children. *Clin Allergy* 1977;**7**:445–53.
31 Office of Population Censuses and Surveys. *Country of birth 1981 census.* London: HMSO, 1983.
32 Patrick JM, Patel A. Ethnic differences in the growth of lung function in children. *Ann Hum Biol* 1986;**13**:307–15.
33 Bhattacharya AK, Banerjee S. Vital capacity in children and young adults in India. *Indian J Med Res* 1966;**54**: 62–71.
34 Edwards RHT, Miller GJ, Hearn CED, Cotes JE. Pulmonary function and exercise responses in relation to body composition and ethnic origin in Trinidadian males. *Proc R Soc London B* 1972;**181**:407–20.
35 Lapp NL, Amandus HE, Hall R, Morgan WKC. Lung volumes and flow rates in black and white subjects. *Thorax* 1974;**29**:185–8.
36 Rossiter CE, Weil H. Ethnic differences in lung function: evidence for proportional differences. *Int J Epidemiol* 1974;**3**:55–61.
37 Hearn CED. Bagassosis: an epidemiological, environmental, and clinical survey. *Br J Ind Med* 1968;**25**: 267–82.
38 Miller GJ, Ashcroft MT, Swan AV, Beadnell HMSG. Ethnic variation in forced expiratory volume and forced vital capacity of African and Indian adults in Guyana. *Am Rev Respir Dis* 1970;**102**:979–81.
39 Cotes JE, Malhotra MS. Differences in lung function between Indians and Europeans [Abstract]. *J Physiol* 1964;**177**:17P–8P.
40 Kamat SR, Thiruvengadam KV, Rao TL. A study of pulmonary function among Indians and assessment of the Wright peak flow meter in relation to spirometry for clinical use. *Am Rev Respir Dis* 1967;**96**:707–16.
41 Malik MA, Moss E, Lee WR. Prediction values for the ventilatory capacity in male West Pakistani workers in the United Kingdom. *Thorax* 1972;**27**:611–9.
42 Cotes JE, Dabbs JM, Hall AM, Lakhera SC, Saunders MJ, Malhotra MS. Lung function of healthy young men in India: contributory roles of genetic and environmental factors. *Proc R Soc Lond* 1975;**191**:413–25.
43 Hsi BP, Hsu KHK, Jenkins DE. Ventilatory function of normal children and young adults: Mexican-American, white, and black. III. Sitting height as a predictor. *J Pediatr* 1983;**102**:860–5.
44 Hamill PVV. Forced vital capacity of children 6–11 years, United States. *Vital and health statistics: Series 11. Data from the National Health Survey, No 164.* Hyattsville: Department of Health, Education, and Welfare, 1978. DHEW publications: No (PHS) 78-1651.