Etiology of Ethnic Differences in Childhood Spirometry

WHAT’S KNOWN ON THIS SUBJECT: There are ethnic differences in lung function, with white people generally having higher values of FVC and FEV1 than people of South Asian origin, whereas differences in forced expiratory flows are absent or less marked. The underlying reasons are unknown.

WHAT THIS STUDY ADDS: Lung function differences were not explained by cultural, socioeconomic, or perinatal factors, nor by environmental exposures or wheezing illness. This suggests that genetic factors are responsible, and supports the use of ethnicity-specific prediction equations for children of South Asian origin.

OBJECTIVES: Age- and height-adjusted spirometric lung function of South Asian children is lower than those of white children. It is unclear whether this is purely genetic, or partly explained by the environment. In this study, we assessed whether cultural factors, socioeconomic status, intrauterine growth, environmental exposures, or a family and personal history of wheeze contribute to explaining the ethnic differences in spirometric lung function.

METHODS: We studied children aged 9 to 14 years from a population-based cohort, including 1088 white children and 275 UK-born South Asians. Log-transformed spirometric data were analyzed using multiple linear regressions, adjusting for anthropometric factors. Five different additional models adjusted for (1) cultural factors, (2) indicators of socioeconomic status, (3) perinatal data reflecting intrauterine growth, (4) environmental exposures, and (5) personal and family history of wheeze.

RESULTS: Height- and gender-adjusted forced vital capacity (FVC) and forced expired volume in 1 second (FEV1) were lower in South Asian than white children (relative difference −11% and −9% respectively, $P < .001$), but PEF and FEF50 were similar ($P > .5$). FEV1/FVC was higher in South Asians (1.8%, $P < .001$). These differences remained largely unchanged in all 5 alternative models.

CONCLUSIONS: Our study confirmed important differences in lung volumes between South Asian and white children. These were not attenuated after adjustment for cultural and socioeconomic factors and intrauterine growth, neither were they explained by differences in environmental exposures nor a personal or family history of wheeze. This suggests that differences in lung function may be mainly genetic in origin. The implication is that ethnicity-specific predicted values remain important specifically for South Asian children. Pediatrics 2013;131:e1842–e1849.

AUTHORS: Marie-Pierre Françoise Strippoli, MSc,a,b Claudia Elisabeth Kuehni, MD, MSc,a Cristian Mihai Dogaru, MD, PhD,a Ben Daniel Spycher, PhD,a Teresa McNally, BSc,a Michael Silverman, MD, FRCPCH,t and Caroline Sarah Beardsmore, BSc, PhDt

aInstitute of Social & Preventive Medicine, University of Bern, Bern, Switzerland; bDepartment of Psychiatry, Lausanne University Hospital, Prilly, Switzerland; and tDivision of Child Health, Department of Infection, Immunity & Inflammation, University of Leicester and Institute for Lung Health, Leicester, United Kingdom

KEY WORDS: ethnicity, lung mechanics, lung function measurements, migration, South Asian

ABBREVIATIONS: FEF50—forced expiratory flow at 50% vital capacity
FEV1—forced expired volume in 1 second
FVC—forced vital capacity
PEF—peak expiratory flow
SES—socioeconomic status

Ms Strippoli designed the study, managed and analyzed the data, and wrote a first version of the manuscript; Prof Kuehni and Dr Spycher designed the study, and provided consultancy on statistical analysis; Dr Dogaru provided consultancy on statistical analysis; Ms McNally performed laboratory measurements and data management; Prof Silverman designed the study and provided consultancy on lung physiology; Dr Beardsmore designed the study, planned and supervised the collection of the data, and provided consultancy on lung physiology; and all authors contributed to the interpretation of the data, revised the drafts, and read and approved the final manuscript.

www.pediatrics.org/cgi/doi/10.1542/peds.2012-3003
doi:10.1542/peds.2012-3003

Accepted for publication Mar 8, 2013

Address correspondence to Claudia E. Kuehni, MD, MSc, Institute of Social and Preventive Medicine, University of Bern, Finkenhubelweg 11, CH-3012 Bern, Switzerland. E-mail: kuehni@ispm.unibe.ch

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2013 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: Supported by the Swiss National Science Foundation (3200B0-122341) and Asthma UK (07/048). Dr Spycher is the recipient of a European Respiratory Society/Marie Curie Joint Research Fellowship (MC 1614-2010).
It has long been known that lung function varies among people of different ethnic origin. Most studies focused on differences in spirometry, showing that white subjects have, at all ages, larger values of height-normalized forced vital capacity (FVC) and forced expired volume in 1 second (FEV1) than either black or Asian populations; reported differences vary from 8% to 17%. Measurements of flow (which may reflect airway caliber rather than volume) have been studied less frequently and have not always been normalized for height. Some reports indicate significant differences in flows among people of various ethnic groups, whereas others show little or no difference. The use of ethnicity-specific prediction equations for lung function has been proposed where such differences have been found, and the recent development of multi-ethnic reference values for spirometry provides a means of adjusting for differences between certain ethnic groups.

The reasons for these differences in lung volumes are largely unknown. Broadly speaking, they might reflect either genetic differences translating into varying body habitus or respiratory muscle strength, or else reflect differences in the environment among ethnic groups. The array of environmental exposures that could affect lung development and function is large. It includes cultural factors, socioeconomic status (SES), intrauterine growth and perinatal health, and a number of environmental exposures, such as diet, indoor and outdoor air pollution, or exposure to infections. Last, differences in lung function at school-age could be explained by a history of asthma or allergy. Among authors reporting differences in lung function between white and South Asians (UK-based studies), few attempted to determine whether these are fully or partly mediated via the environment. These studies pointed to an effect of SES on ethnic differences in lung function, but were limited in that the available data were cross-sectional, and recruitment was based in schools rather than being from a random sample of the population.

In a population-based birth cohort, which includes a large proportion of South Asian children and detailed data on environmental exposures throughout childhood, we therefore compared lung function between UK-born white children and UK-born South Asian children. In addition, we assessed whether any differences in lung function between these groups were explained by cultural, socioeconomic, or perinatal factors; by differences in environmental exposures; or by a personal and family history of wheeze.

METHODS

Study Design and Population

The Leicester Respiratory Cohort is a community-based random sample of children born from 1993 to 1997 in Leicestershire, United Kingdom, whose parents received standardized questionnaires in 1998, 2001, 2003, 2006, and 2010. A nested sample that had answered the first and at least 1 follow-up questionnaire (2001 or 2003; n = 4100) was invited for lung function and allergy tests, including 2974 white children and 1126 children of South Asian ethnicity (mother self-identified as Indian, Pakistani, Bangladeshi, or other). A large proportion of the Leicestershire population originates from the Indian subcontinent (mainly Gujarat). These families migrated to the United Kingdom either directly from India or indirectly via a stay in East Africa. Additional self-reported information on maternal age, country of birth, ethnic origin, religion, and language was available from maternity records. The Local Research Ethics Committee approved the study and written consent was obtained from parents and children.

Respiratory Questionnaire

Families completed standardized questionnaires on respiratory symptoms, diagnoses, health care use and treatments for wheeze, environmental exposures, ethnicity, and SES at the time of the laboratory visit (2006–2010) when children were aged 9 to 14 years. Additional questionnaires were completed in 2001 and/or 2003. Pubertal stage was assessed in a subgroup of children with the Carskadon and Acebo self-report version of the pubertal development scale derived from 5 indices of pubertal growth (see Supplemental Information). The mean item score was used as a continuous measure.

Measurements

Children performed spirometry (Pneumotrac, Vitalograph, Ennis, Ireland) before and 15 minutes after salbutamol (400 µg, by metered dose inhaler and Volumatic spacer [Glaxo, Uxbridge, UK]) using standard techniques. The main outcome was postbronchodilator lung function, because it reflects structural lung development rather than reversible airway obstruction. We recorded FVC, FEV1, peak expiratory flow (PEF), and forced expiratory flow at 50% vital capacity (FEF50). The z-scores were derived from the Global Lung Function 2012 prediction equations.

Statistical Analysis

We performed analyses with Stata 11.2 (Stata Corp, College Station, TX). To avoid biases related to exclusion of children with missing values, we used multiple imputation. We created 20 complete datasets using the Multivariate Imputation by Chained Equations procedure. These datasets were analyzed separately and results from each were combined using Rubin rules. More details are provided in the supplemental information.
We used multiple linear regressions to compare log-transformed lung function measurements between white and South Asian children. Results are reported as relative difference from measurements of white children. The baseline analysis was adjusted for anthropometric data only (age, gender, height, and weight). Because of the nonlinear relationship between lung function measurements and anthropometric measures, quadratic terms for age, height, and weight were also included. Multiple linear regressions were used as well to compare z-scores derived from the Global Lung Function 2012 prediction equation between ethnic groups.

In 5 consecutive models, we then tested whether the findings from this baseline model (ie, relative differences in lung function between ethnic groups) were explained by the following: (1) cultural and ethnic factors (maternal country of birth, language, religion); (2) SES (Townsend deprivation score [a composite area-based deprivation score using information on unemployment, overcrowding, car ownership, and home ownership], parental education [highest level of the parents], crowding, single parenthood); (3) perinatal data reflecting intrauterine growth (gestational age, birth weight); (4) environmental exposures (pre- and postnatal tobacco exposure, breastfeeding, fuels used for cooking and heating, number of older siblings, early child care, pets); and (5) a personal or family history of wheeze or allergy (doctor-diagnosed asthma, shortness of breath, frequency [number of episodes] of wheeze, asthma treatments, parental history of asthma or hay fever). Townsend deprivation score, prenatal tobacco exposure, breastfeeding, number of older siblings, early child care, and parental history of asthma or hay fever were assessed in the first questionnaire, 1998, 8 to 10 years before lung function testing.

Perinatal data were collected at birth (see Supplemental Information for detailed description of the variables).

To test the robustness of the findings, we also performed sensitivity analyses, using (1) the complete dataset (without imputation); (2) prebronchodilator rather than postbronchodilator lung function (to test the effect of reversible airway obstruction); and (3) additional adjustment for pubertal development scale.

RESULTS
Response Rates and Population Characteristics
A nested sample of 1484 (36%) of 4100 cohort children agreed to participate in laboratory measurements. Of these, we excluded 121 children with mixed ethnicity, leaving 1363 children for the analysis. Participants in the laboratory visit were more likely to be white, breastfed, of higher SES and to ever report respiratory symptoms than nonparticipants, but less likely to have attended child care (children’s nursery or kindergarten [Supplemental Table 3]).

The study population included 1088 (80%) white and 275 (20%) South Asian children of mean (SD) age 12.2 (1.2) years. When looking at cultural factors among South Asian children, 70 (25%) had UK-born mothers, and 205 (75%) had immigrant mothers (123 from India, 79 from Africa, and 3 from other countries). The largest linguistic subgroup (114) was Gujarati-speaking. Half of the South Asian families (47%) were Hindu. Characteristics of participating South Asian families have been described in detail earlier.30,31 SES differed between ethnic groups, with South Asian children being more deprived (higher Townsend score, poorer parental education, more overcrowding) but less likely to live in single-parent households (Table 1). A number of environmental exposures differed between groups. Compared with their white peers, few South Asian children were exposed to pre- or postnatal tobacco smoke or to a household pet. In contrast, they were less likely to have been breastfed and to live in a house with gas as the only cooking fuel. Parents of South Asian children were less likely to suffer from asthma or hay fever, whereas the children’s personal history of wheeze did not differ. Finally, South Asian children had a significantly lower birth weight (3.07 vs 3.30 kg) and tended to have a lower gestational age at birth (38.93 vs 39.17 weeks [Table 2 and Supplemental Table 4]).

Ethnicity and Post-Salbutamol Spirometry
After adjusting for age, gender, height, and weight (baseline analysis), mean post-salbutamol FVC was lower in South Asian compared with white children, with a relative difference (95% confidence interval) of −10.8% (−12.4 to −9.2, P < .001, Table 2, Fig 1A) and an estimated absolute difference in z-scores of −0.24 (−0.38 to −0.10). Adjusted mean post-salbutamol FEV1 was also lower in South Asian children, with a relative difference of −9.2% (−10.8 to −7.5, P < .001 [Table 2, Fig 1B]) and an estimated absolute difference in z-scores of −0.28 (−0.39 to −0.11). The relative difference in FVC exceeded that of FEV1, so that FEV1/FVC was higher in the South Asian children (relative difference 1.8% [0.9 to 2.6, P < .001]). Post-salbutamol PEF and FEF25 were similar in both ethnic groups (all P > .5, Table 2, Fig 2A and B).

The results of the explanatory models, which included adjustments for cultural and ethnic factors (model 1), SES (model 2), perinatal data (model 3), environmental exposures (model 4), or personal and family history of wheeze (model 5), were comparable to the main models. Lung volumes remained lower and midexpiratory flows similar in...
TABLE 1 Characteristics of the Study Population by Ethnic Group (n = 1365)

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>White (n = 1088)</th>
<th>South Asian (n = 275)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Boys, %</td>
<td>571</td>
<td>52.5</td>
<td>149</td>
</tr>
<tr>
<td>Townsend deprivation score (tertiles)abc</td>
<td>417</td>
<td>38.3</td>
<td>34</td>
</tr>
<tr>
<td>Low</td>
<td>402</td>
<td>36.9</td>
<td>73</td>
</tr>
<tr>
<td>Medium</td>
<td>250</td>
<td>23.0</td>
<td>165</td>
</tr>
<tr>
<td>High</td>
<td>71</td>
<td>6.5</td>
<td>41</td>
</tr>
<tr>
<td>Parental educationh</td>
<td>319</td>
<td>29.3</td>
<td>71</td>
</tr>
<tr>
<td>No qualification</td>
<td>353</td>
<td>32.1</td>
<td>84</td>
</tr>
<tr>
<td>NQF 1 or 2</td>
<td>327</td>
<td>30.1</td>
<td>71</td>
</tr>
<tr>
<td>NQF 3 – 5</td>
<td>107</td>
<td>9.8</td>
<td>94</td>
</tr>
<tr>
<td>NQF 6 or above</td>
<td>150</td>
<td>13.8</td>
<td>16</td>
</tr>
<tr>
<td>Parental history of hay feverc</td>
<td>531</td>
<td>48.8</td>
<td>93</td>
</tr>
</tbody>
</table>

NQF, National Qualification Framework: NQF 1 or 2 equates to GCSE (general certificate of secondary education) examinations (usually taken at age 16), NQF 3 equates to A-level (advanced level general certificate of education) examinations (taken at age 18), and NQF 6 is equivalent to a first degree.

* P value (χ2 test) comparing children of white mothers and children of South Asian mothers.

a Percentages may not add up to 100% due to missing values.

b At time of recruitment.

c In this context, “current wheeze, shortness of breath or asthma treatment” indicates that the child was reported to display this characteristic in the 12 mo before measurement. It does not indicate that the child was symptomatic or receiving treatment at the time of measurement.

d Use of inhaled bronchodilators or corticosteroids.

South Asian children compared with their white peers, suggesting that the differences were not explained by the factors tested (Table 2).

Additional Models

When we repeated the analysis, including (1) records with complete data only without using multiple imputation (Supplemental Table 5), (2) prebronchodilator lung function (Supplemental Table 6), and (3) additional adjustment for pubertal stage (Supplemental Table 7), results were again comparable to the main analysis.

DISCUSSION

This large, population-based study confirmed that, after adjusting for gender, age, height, and weight, children of South Asian origin have smaller lung volumes (FVC and FEV₁) than their white peers but similar peak flow and midexpiratory flows. These differences in lung function were not explained by cultural, socioeconomic, perinatal, or environmental factors or by personal or family history of wheeze. We cannot rule out the influence of other, unmeasured factors, but we speculate that the differences are largely genetic rather than environmental in origin.

A major strength of this study is that the participants were drawn from a well-characterized birth cohort, with a wealth of information on social and environmental exposures and early symptoms, assessed before and independently of the outcome (lung function). The ethnic groups were closely matched for age and, in contrast to other studies on ethnic differences, the South Asian children in our cohort were of relatively homogeneous ethnic origin. The study was conducted in a single center by a small number of technicians using standardized equipment and techniques. Measurements were made over the same time periods for all children. Thus, the differences in lung function cannot be attributed to center effects and are unlikely to be artifactual. Although changes in lung function occasioned by puberty tend to occur in late puberty and our oldest children were only 14 years, the impact of gender on asthma in childhood and adolescence is known to vary with age. We therefore adjusted for pubertal status but found no evidence that the results were influenced by differences in timing of puberty and associated differences in lung growth. Results were similar when using multiple imputation and complete case analysis, suggesting that missing data did not lead to bias. We chose to use postbronchodilator spirometry as the primary outcome variable because this constitutes the best index of lung function that can be achieved at the time of testing, and avoids potential complications of ethnic differences in...
TABLE 2  Relative Differences in Anthropometric Measurements and Post-salbutamol Spirometry in South Asian Compared With White Children (Adjusted Analyses, n = 1363)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>White Children (Reference)</th>
<th>South Asian Children</th>
<th>% Relative Difference From White Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, cm</td>
<td>152.44 ± 152.87</td>
<td>−1.00</td>
<td>−0.30 to 0.30</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>45.61 ± 45.10</td>
<td>−1.59</td>
<td>−4.50 to 1.41</td>
</tr>
<tr>
<td>Birth weight, kg</td>
<td>3.30 ± 3.33</td>
<td>−6.85</td>
<td>−8.78 to −4.88</td>
</tr>
<tr>
<td>Gestational age, wk</td>
<td>39.17 ± 39.30</td>
<td>−0.60</td>
<td>−0.10 to 0.10</td>
</tr>
<tr>
<td>FEV1, L</td>
<td>2.820 ± 2.79</td>
<td>−10.77</td>
<td>−12.37 to −9.24</td>
</tr>
<tr>
<td>Cultural factors (1)</td>
<td>2.853 ± 2.80</td>
<td>−12.72</td>
<td>−15.04 to −10.33</td>
</tr>
<tr>
<td>SES (2)</td>
<td>2.819 ± 2.78</td>
<td>−10.60</td>
<td>−12.28 to −8.97</td>
</tr>
<tr>
<td>Intrauterine growth (3)</td>
<td>2.819 ± 2.78</td>
<td>−10.60</td>
<td>−12.19 to −8.97</td>
</tr>
<tr>
<td>Environmental exposures (4)</td>
<td>2.821 ± 2.78</td>
<td>−10.86</td>
<td>−12.80 to −8.88</td>
</tr>
<tr>
<td>Personal and family history of wheeze (5)</td>
<td>2.822 ± 2.80</td>
<td>−11.13</td>
<td>−12.65 to −9.52</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural factors (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrauterine growth (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental exposures (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal and family history of wheeze (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEF, L/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural factors (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrauterine growth (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental exposures (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal and family history of wheeze (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEF100, L/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural factors (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrauterine growth (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental exposures (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal and family history of wheeze (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CI, confidence interval.
Baseline analysis (model 0): adjusted for age, gender, height, weight.
Cultural factors (model 1): model 0+: mother’s country of birth, language, religion.
SES (model 2): model 0+: Townsend score, parental education, crowding, single parenthood.
Intrauterine growth (model 3): model 0+: birth weight, gestational age.
Environmental exposures (model 4): model 0+: prenatal tobacco exposure, postnatal tobacco exposure, breastfeeding, cooking, heating, number of older siblings, early child care, pets.
Personal and family history of wheeze (model 5): model 0+: frequency of wheeze, doctor diagnosis of asthma, shortness of breath, asthma treatment, parental history of asthma, parental history of hay fever.
* Adjusted for age and gender only.
** Adjusted for gender and gestational age only.
† Adjusted for gender only.

However, this response rate is not unusual for laboratory measurements in a population-based cohort. The sample analyzed might not be fully representative of the entire population of the Leicestershire area. South Asian children may be less well represented because, although overrepresented in the original sample, they were less likely to participate in measurements (Supplemental Table 3). As in previous studies, lung volumes in South Asian children in this study were about 10% to 11% smaller than in white peers. This is consistent with earlier reports from us and others.2,9,12,27 In a previous cross-sectional study in Leicestershire, using a different study population, we had found FVC to be 13% lower and FEV1 11% lower in South Asian children aged 6 to 11 years compared with white peers.27 Differences in age and pubertal stage might explain the small differences between this and the current study. In 11- to 13-year-olds from London, FVC and FEV1 were reported to be about 8% to 9% lower in Indian than white children.12 A London-based study of preschool children showed that South Asian children had reduced spirometry when compared with their white counterparts of −0.69 of a SD for FVC and −0.76 of a SD for FEV1; differences that equate to a reduction of −11%.13 Recently published data collated from 26 countries produced reference equations that included adjustment for 4 ethnic groupings from the age of 3 to 95 years, but adjustment for populations from the Indian subcontinent could not be derived.18 This was because few data sets were available for analysis and they did not combine well; there is a need for more data from Indian and Pakistani individuals.

We found that there was a small but statistically significant difference in FEV1/FVC between the ethnic groups, with the South Asian children having bronchodilator response. If we used baseline spirometry, however, the results were not different (Supplemental Table 6). Limitations include the modest response rate for the laboratory examinations (36%), which has reduced power and could potentially have introduced bias.
an increased value. Although not reported at the time, data from our previous study also shows a larger FEV1/FVC in South Asian children.27 Data from the largest collation of studies from different ethnic groups indicates that, with the exception of Southeast Asian individuals (defined as peoples from Thailand, Taiwan, and China south of the Huaihe River and Qinling Mountains) FEV1/FVC does not differ significantly between people of different ethnic groups.18 This suggests that in most cases the differences in FEV1 and FVC are proportional, regardless of ethnicity. Our results are contrasting and more closely resemble those of Southeast Asians.18 The nonproportional differences in FEV1 and FVC that we have observed may explain why we did not see ethnic differences in PEF or FEF50, which would be expected with a proportional change in lung volumes. An alternative explanation for our finding that PEF and FEF50 did not differ between white and South Asian children could be that there are differences in elastic recoil of the lung, but data to explore this speculation are lacking.

The main determinants of lung function are gender and height. One well-recognized explanation for ethnic differences in height-normalized lung function is a difference in body proportions (trunk:leg ratio), as shown for black African and Afro-Caribbean people.20,42 We did not measure sitting height in the current study, but our previous work with South Asian and white children from Leicestershire indicated that the trunk:leg ratio did not explain ethnic differences in FEV1 and FVC,27 confirming earlier observations.9 Another UK-based study that included >700 white children and a similar number of South Asian children reported some differences in body proportion but these were insufficient to account fully for ethnic differences in lung volumes.12

The novelty of our study is the careful and systematic assessment of a large array of factors that could potentially explain ethnic differences in lung function. SES, variably defined, has been found to be associated with poorer health in general and reduced lung function (see Hegewald and Crapo21 for a review). Potential mechanisms linking SES and lung function include poorer nutrition (including maternal nutrition during pregnancy) leading to poorer growth, increased rates of respiratory infection, and increased likelihood of exposure to air pollution, including cigarette smoke. A study including >10 000 children concluded that SES (based on parental education) did not affect height-normalized FVC or FEV1,43 but several other reports

Figure 1

Post-salbutamol FVC and FEV1 in white and South Asian children (unadjusted results, n = 1363). Solid line, o, white children; dashed line, +, South Asian children.
As in the study by Whitrow and Harding, we found no evidence that the ethnic differences were explained by differences in cultural factors and SES. A number of environmental exposures differed significantly between ethnic groups in our population (pre- and postnatal tobacco smoke, breastfeeding, cooking and heating fuels, number of older siblings, early child care, and pets, all accounted for in model 4). However, none of them helped to explain the smaller lung volumes in South Asian children. Birth weight of South Asian children was significantly lower from that of white children, and there was also a trend for a lower gestational age. Parental history of asthma and hay fever was lower in South Asian children, and pattern and treatment of wheezing illness did not differ. However, as for socioeconomic, cultural, and environmental factors, these did not explain the lower lung volumes in South Asian compared with white children.

CONCLUSIONS
We confirmed differences in lung function between UK-born white and South Asian children growing up in the same city and showed that these differences were not explained by cultural, socioeconomic, or environmental condition, or by differences in birth weight, gestational age, or a personal and family history of wheeze. This suggests that ethnic differences in height-adjusted lung function between white and South Asian children may be largely genetic in origin. It follows that there is a need for reference equations for predicting lung function specifically for South Asian children.

ACKNOWLEDGMENTS
We thank the parents and children of Leicestershire and Rutland for participating, and Tony Davis, Specialist Community Child Health Services, Leicester City Primary Care Trust, for his assistance.

REFERENCES

**FIGURE 2**
Post-salbutamol PEF and FEF_{50} in white and South Asian children (unadjusted results, n = 1363). Solid line, o, white children; dashed line, +, South Asian children.


13. Sonnappa S, Bastardo CM, Sta


Etiology of Ethnic Differences in Childhood Spirometry
Marie-Pierre Françoise Strippoli, Claudia Elisabeth Kuehni, Cristian Mihai Dogaru, Ben Daniel Spycher, Teresa McNally, Michael Silverman and Caroline Sarah Beardsmore

Pediatrics 2013;131:e1842; originally published online May 27, 2013; DOI: 10.1542/peds.2012-3003
Etiology of Ethnic Differences in Childhood Spirometry
Marie-Pierre Françoise Strippoli, Claudia Elisabeth Kuehni, Cristian Mihai Dogaru, Ben Daniel Spycher, Teresa McNally, Michael Silverman and Caroline Sarah Beardsmore

Pediatrics 2013;131:e1842; originally published online May 27, 2013;
DOI: 10.1542/peds.2012-3003

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/131/6/e1842.full.html