Review Article

Socio-environmental factors and lung function

M. STEINBERG, MARGARET R. BECKLAKE

Summary

The literature was reviewed to assess whether the evidence implicating socio-environmental (SE) factors as determinants of adult lung function was sufficient to require that they be taken into account in epidemiological studies, together with other factors, such as age and smoking. In six studies involving 11 000 adults resident in the USA, France and Denmark forced expiratory volume in 1 second was related to social class and/or one of a number of other factors including education, area of residence and housing status. Trends in three other studies involving approximately 15 000 children resident in the UK and the USA were similar. The consistency of the findings makes it difficult to escape the conclusion that SE factors should be taken into account in comparisons of lung function between populations when the purpose is to assess the role of other environmental factors such as occupational exposure.

Lung function tests are an important part of the clinical assessment of respiratory illness, in particular when degree of impairment or disability needs to be evaluated, for instance for compensation purposes. Comparison of measured lung functions with reference values derived from published data on healthy populations is necessary given the many factors other than disease, the focus of clinical assessment, which contribute to between-individual variation in lung function. Identical considerations apply to the use of lung function tests to assess the respiratory status of populations. Thus in examining work forces subject to particular occupational exposures, comparison with non-exposed or other healthy populations becomes a central issue.

Attention has recently been directed to the influence of socio-environmental (SE) factors on respiratory health status (including lung function) in the columns of this Journal. The purpose of this study is to review the medical literature on the topic in order to evaluate three issues: (i) the role of SE factors vis-à-vis that of other determinants of lung function; (ii) whether they should be taken into account in epidemiological studies, in particular those focused on work forces; and, if so, (iii) the operational guidelines for so doing. This is particularly relevant in the RSA where SE factors are linked to ethnicity (Table I). In addition, unanswered questions and future lines of research will be discussed.

Sources of variation in lung function

In order to assess the contribution of SE factors to variation in lung function, it is necessary to take into account the other known sources of variation. These can conveniently be con-
The term SE is used here in a collective sense to describe the social, economic and environmental factors which relate to social class and/or socio-economic status. Some of the SE factors — definition and measurement

The relationship between general ill-health and socio-economic status in adults have been the subject of study since the 19th century when analysis of the Registrar-General's reports on deaths in the UK led Dr William Farr to speculate that hardship arising from poverty and its consequences in housing, nutrition, hygiene and clothing might contribute to the striking differences in mortality in men engaged in different occupations. Although the overall mortality rate has fallen considerably between the 19th and early 20th centuries, mortality rates and life expectancy persist. In the RSA, where socio-economic factors and ethnicity are linked, marked differences in the adult mortality patterns of the different racial groups have been reported in this journal.

The relationship between general ill-health and SE status in childhood is, according to a recent review, poorly documented. Nevertheless, the authors conclude that the evidence available is consistent and indicates that many childhood health problems, illnesses and their sequelae are more common among poor children than among non-poor children (authors' terminology), as defined by family income. In addition, the authors caution that causality cannot be inferred from the data they reviewed, and stress the need for more basic research on the social correlates of disease. Childhood mortality patterns in the different South African racial groups are consistent with these conclusions. SE factors are also important determinants of childhood growth patterns. For instance, growth standards developed in industrialized countries and previously thought to be inappropriate for developing countries were recently shown to describe growth patterns in children of the upper social classes in several developing countries. These findings led the authors to conclude that SE status rather than race or ethnicity was the primary determinant.

### Relationship of respiratory ill-health to SE factors

This study focuses on population-based (epidemiological) studies of the relationship of SE factors to respiratory symptoms and to lung function. Most have been undertaken to

### Table I. Distribution of the South African Work Force by Occupation in 1977

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>White (%)</th>
<th>Coloured (%)</th>
<th>Asian (%)</th>
<th>Black (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Owners/managers</td>
<td>11.3</td>
<td>0.6</td>
<td>8.2</td>
<td>0.5</td>
<td>3.9</td>
</tr>
<tr>
<td>II</td>
<td>White collar (total)</td>
<td>60.1</td>
<td>24.8</td>
<td>40.9</td>
<td>12.9</td>
<td>25.1</td>
</tr>
<tr>
<td></td>
<td>(a) Professional/semiprofessional</td>
<td>11.5</td>
<td>5.5</td>
<td>4.4</td>
<td>2.5</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>(b) Clerical, technical and other non-manual</td>
<td>43.3</td>
<td>17.2</td>
<td>34.6</td>
<td>9.2</td>
<td>20.9</td>
</tr>
<tr>
<td>III</td>
<td>Blue collar (total)</td>
<td>28.7</td>
<td>74.6</td>
<td>50.9</td>
<td>86.7</td>
<td>67.0</td>
</tr>
<tr>
<td></td>
<td>(a) Skilled</td>
<td>22.7</td>
<td>12.6</td>
<td>7.3</td>
<td>5.0</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>(b) Semiskilled</td>
<td>4.9</td>
<td>25.2</td>
<td>24.8</td>
<td>19.7</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>(c) Unskilled</td>
<td>1.1</td>
<td>32.8</td>
<td>18.8</td>
<td>62.0</td>
<td>39.4</td>
</tr>
</tbody>
</table>

* Adapted from Sinkins and Hindson.
elucidate the early natural history of chronic obstructive respiratory diseases. It was originally thought that chronic bronchitis (mucus hypersecretion) and chronic airflow limitation (airflow obstruction) were sequential events in the same disease process; now it is believed that they are independent syndromes, probably arising in different parts of the bronchial tree (mucus hypersecretion from disease in large airways, airflow limitation from disease in small airways) with some common and some independent risk factors. In addition the prognosis for the two syndromes is different; mucus hypersecretion appears to be largely if not entirely reversible on quitting smoking, chronic airflow limitation only partly so. In this study mucus hypersecretion and chronic airflow limitation are therefore considered separately.

Social-class gradients in the prevalence of respiratory symptoms in adults, in particular cough and sputum, were first observed in early studies in the UK, and confirmed in a nation-wide study conducted through the College of General Practitioners using standardized methodology. Rates in the lower social classes were approximately double those in the upper social classes using education as the indicator. The smaller differences in smoking habits had no material effect on the social class gradient. In the USA, gradients related to education and occupation have been reported within smoking categories. However, in contrast with the British studies, poor occupational, economic or educational circumstances had only a weak deleterious effect in comparison with the much greater effect of smoking. Explanations of the UK/USA differences may lie in the SE gradients spanned, probably less for instance in the relatively non-industrialized and largely rural area of Tecumseh, Michigan, than in many UK studies which included that country’s industrial heartland.

The relationship of SE factors to lung function in six population-based studies in adults is summarized in Table II. One of the earliest studies to address this issue was confined to men aged 35-64 years, all non-smokers. A gradient of approximately 400 ml in FEV1 was found between those with the highest and the lowest social-position score based on income, education and occupation. In three other studies, abnormality rates for FEV1 were consistently higher in subjects in the less favourable than in the more favourable SE categories, after taking smoking into account. In a 12-year longitudinal study of workers in the Paris area, social class, smoking and occupational exposure (to dust, gas or heat) were shown to be independently related to annual FEV1 decline, the effect of social class being only slightly less than that of the other two factors. Finally, in a Danish study of men in clean jobs, FEV1 and maximal mid-expiratory flow rate (MMER) were shown to be negatively related to years spent in residences without central heating, and the authors concluded that poor dwelling conditions in childhood and adolescence are associated with the development of central and peripheral airway abnormality in adult life. Other studies (see also below) have also suggested that events in childhood and adolescence can influence adult lung function.

Social-class gradients for respiratory complaints and conditions have also been reported among children and adolescents. In the UK, for instance, a pronounced social-class gradient for cough and a history of bronchitis was shown in 6-10-year-olds, rates in the lower two classes being 2-3 times those in the upper two classes. This study was based on over 10,000 children living in various urban and rural areas. In a second UK study, the major determinants of cough in 20-year-olds were smoking habits and a history of respiratory-tract illness before the age of 2 years, while social class and air pollution had little effect. In Australia, the social-class gradients for bronchitis appear to be less consistent. In the USA a pilot study of respiratory disease in inner-city black children in Baltimore showed the illness rates to be universally higher for those in public v. private housing. However, the authors concluded that housing status was less important than other socio-economic variables as a determinant of illness rates.

The relationship of SE factors to lung function in four population-based studies of children is summarized in Table III. In two studies (one in the UK and one in the USA), both covering a wide age range (5-14 years) low socio-economic status (based on parental occupation and education) was associated with lower lung function. In the UK

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**TABLE II. THE RELATIONSHIP OF SE FACTORS TO LUNG FUNCTION IN SELECTED POPULATION-BASED STUDIES OF ADULTS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>No. (age yrs)</th>
<th>SE factors</th>
<th>Lung function</th>
<th>Relationship of lung function to SE factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stebbings14 (Maryland, USA)</td>
<td>1971</td>
<td>410 men (35-64)</td>
<td>SE score including occupation, income and education</td>
<td>FEV1 PEFR</td>
<td>Strong negative relationships; only non-smoking men studied</td>
</tr>
<tr>
<td>Lebowitz15 (Arizona, USA)</td>
<td>1977</td>
<td>3 485 men, women and children</td>
<td>Income, education, occupation and overall FEV1</td>
<td></td>
<td>Negative relationships to income and education but not to SE score</td>
</tr>
<tr>
<td>Cohen et al.16 (Maryland, USA)</td>
<td>1977</td>
<td>Approx. 2 000 men and women</td>
<td>SE score Residence classified by census data FEV1 DCO</td>
<td></td>
<td>Abnormality rates greater in lowest compared to highest SE group</td>
</tr>
<tr>
<td>Higgins et al.17 (Michigan, USA)</td>
<td>1977</td>
<td>4 699 men and women (20-74)</td>
<td>Income, education, occupation and in 1 626 employed men FEV1</td>
<td></td>
<td>Negative relationships to all SE factors but all weaker than smoking</td>
</tr>
<tr>
<td>Rasmussen et al.18 (Denmark)</td>
<td>1978</td>
<td>218 men (40-69)</td>
<td>Residential history (yrs in unheated homes) FEV1</td>
<td></td>
<td>Negative relationship to duration of residence in unheated homes</td>
</tr>
<tr>
<td>Kaufmann et al.19 (Paris)</td>
<td>1979</td>
<td>556 men (30-54 in 1960)</td>
<td>Occupation Annual decline in FEV1</td>
<td></td>
<td>Influence of occupational category on decline only in FEV1, slightly less than that of smoking</td>
</tr>
</tbody>
</table>

PEFR = peak expiratory flow rate; FEV1 = forced expiratory volume in 1 s; DCO = diffusing capacity of the lungs for CO; CC = closing capacity.
study, lung function was measured by peak expiratory flow rate; the SE effect was modest (3–5%) and shown in half the age-sex subgroups examined; additional factors influencing lung function were area of residence and family size. In the USA study, lung function was measured by spirometry and an SE effect of approximately 2% found in FVC and FEV₁.₂⁸ Parental smoking habits, not examined in the UK study, were also taken into account; the effects shown were primarily of mothers’ smoking habits on the lung function of girls.₂⁵ In the other two studies,₂⁶,₂⁷ in which the SE factor examined was housing status, the relationship to lung function was less evident. Indeed, in the study carried out in Wales,₂⁶ lung function was, contrary to expectation, better in children living in traditional houses than in those in modern council houses. In the USA study, the authors concluded that socio-economic variables other than housing status are likely to be more important.

**Discussion**

What is the role of SE factors relative to other determinants of lung function?

In answer to this question, the evidence reviewed can be summarized as follows:

1. In six studies involving over 11 000 adults resident in the USA, France and Denmark, FEV₁ was lower in men and women in less favourable occupational (and/or income) circumstances. These differences were not explained by the smoking habit and were as large as 400 ml in one study.₁⁴

2. Rates for respiratory symptoms also showed a gradient in relation to SE status which was not explained by age or smoking.

3. The influence of SE factors on respiratory health status was not confined to adults. In studies involving over 14 000 children resident in the UK and the USA, measurements of ventilatory function were of the order of 3–5% lower in the children of parents in less favourable occupational and/or educational circumstances.

4. Of the various indicators of SE status used, occupation (personal in adults, parental in children) shows the strongest links to respiratory symptoms and/or illness and/or function.

Should SE factors be taken into account in epidemiological studies?

Given the consistency of the findings in adults, it is difficult to escape the conclusion that SE factors must be taken into account in between-population comparisons of lung function, frequently the basis for analysis in epidemiological studies. This can usually best be done by matching the populations to be compared for SE factors, e.g. selecting the reference (or non-exposed) population from within the same or a similar work force. In this way residence, economic and educational status are likely to be similar. The alternative approach would be to record indicators of SE status in both exposed and non-exposed populations and to take them into account in analysis. SE factors are particularly relevant when the purpose is to assess the impact of environmental factors, for instance a specific occupational exposure.

What guidelines can be offered for measurement of SE factors in population (epidemiological) studies?

Social inequality has traditionally been measured in terms of occupation. One of the first classifications to employ occupation as an indicator was that of the Registrar-General’s office in Britain in 1911,₁³ and these occupational categories have frequently been used to construct social classes. Other similar classifications were subsequently developed.₁₃ Recently, there has been considerable interest in alternatives, either single indicator measures (e.g. education level, income) or composite indicators which employ two or more indicators of social difference. In general, these have not proved as sociologically valid as occupation, which is consistently correlated with income, living standards and very probably access to health care.ₓ This has resulted in the recommendation that the choice of classification to be used in any particular study should depend on study objectives, age and composition of the study population (in particular the extent to which men of working age are included) and any restrictions on data collection.₁₃

In addition, SE indicators are likely to be country-specific.₁⁹ This makes it necessary to develop a suitable occupational-social-class classification for the RSA. One such classification, based on analysis of occupation by race in five Department of Manpower Surveys between 1969 and 1977, has been published and the findings for 1977 are summarized in Table I. This or another such classification, with or without additional information, could form the basis for an operational definition of SE status for use in any future epidemiological studies of lung function in the RSA. Of interest is the opinion expressed by some USA researchers that it may be possible to unravel

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**TABLE III. THE RELATIONSHIP BETWEEN SE FACTORS AND LUNG FUNCTION IN SELECTED POPULATION-BASED STUDIES OF CHILDREN**

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>No. (age yrs)</th>
<th>SE factors</th>
<th>Lung function</th>
<th>Relationship of lung function to SE factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holland _et al._²² (Kent, UK)</td>
<td>1969</td>
<td>10,971 (5 - 14*)</td>
<td>Area of residence, social class, family size</td>
<td>PEFR</td>
<td>Negative relationships to all factors, strongest to area of residence</td>
</tr>
<tr>
<td>Yarnell and St Leger²⁶ (Wales)</td>
<td>1977</td>
<td>214 (7 - 11)</td>
<td>Housing status (traditional, modern)</td>
<td>MMEF</td>
<td>MMEF negatively related to modern housing</td>
</tr>
<tr>
<td>Spivey²⁷ (Baltimore, USA)</td>
<td>1979</td>
<td>25 (6 - 10)</td>
<td>Housing status (public, private)</td>
<td>FEV₁.₇⁵</td>
<td>Lower in public housing group</td>
</tr>
<tr>
<td>Vedal _et al._²⁸ (Pennsylvania, USA)</td>
<td>1984</td>
<td>4071 (5 - 14)</td>
<td>Index based on parents’ education</td>
<td>FVC</td>
<td>Negative relationship to FVC, FEV₁.₇⁵</td>
</tr>
</tbody>
</table>

*Children who smoked were excluded from the analysis, which also took into account parental smoking.

MMEF = maximum mid-expiratory flow rate; FVC = forced vital capacity; FEV₁.₇⁵ = forced expiratory volume in 0.75 s; PEFR = peak expiratory flow rate; FEV₁ = forced expiratory volume in 1 s.
the confounding effects of SE status and race only when there is substantial representation of all groups in the middle-class category. Given the rapid penetration of South African blacks into white-collar jobs and the fact that the data in Table I are 9 years out of date, the time may be ripe for such studies in this country.

Unanswered questions and future research

An important unanswered question relates to the nature of the links between SE status and impaired lung function in adults. It is possible that the relationship is direct, i.e. that the concomitants of less favourable SE status in adult life lead directly to impaired lung function. These include more frequent lower respiratory tract illness, less easy access to medical care and exposures to higher levels of community and domestic air pollution, in addition to and independent of any occupational exposures. Another possibility is that the relationship is indirect and attributable to childhood respiratory insults which affect lung growth and development and lead to lower lung function persisting into adult life. In the second hypothesis, the link to SE factors is via childhood respiratory illnesses, more frequent and more severe in children from poor homes, and SE factors would therefore affect lung function in adult life despite upward social mobility. The two hypotheses are not necessarily mutually exclusive.

Linked to the first question is a second question, raised by Myers in the columns of this Journal, to what extent are the differences in lung function reported in different South African racial groups the consequence of differences in SE status?

A collaborative research programme involving medical groups in different parts of the country has been proposed to address this issue. Its purpose would be: (i) to document the relationship of lung function to personal characteristics which describe body stature (such as height and sitting height) in our various racial groups; and (ii) to relate adult lung function to childhood respiratory health. A requirement of the studies which could be carried out in different centres would be that they be epidemiological (i.e. population-based) in concept and that SE indicators be recorded using standardized criteria in order that their relationships to (i) and (ii) above could be assessed.

To minimize the effect of technical factors, it would be essential to standardize the methodology for recording respiratory histories, for measuring lung function and for analysing data. To develop suitable SE indicators, an essential preliminary to such studies and the key to their success, input from all sources including the social sciences should be sought.

Besides contributing to the better understanding of lung function and its determinants, such studies would provide reference values for use in the RSA. It has been pointed out elsewhere that given the striking differences between values reported for different populations even after standardization for the known sources of variation, no single set of reference values is likely to be applicable to all populations and in all circumstances. For these reasons, it is appropriate to gather local data for use not only in the public health (epidemiological) context but also for use in clinical laboratories.

The authors thank the following colleagues for helpful criticism: Professor S. Benatar and Dr J. S. Myers, University of Cape Town; Professor A. de Kock, University of Stellenbosch; and Professor J. C. A. Davies and Drs A. Zwi and U. Laloo, National Centre for Occupational Health. The opinions expressed in the review are those of the authors.

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35. Halichts JP, Martarrel R, Yarbrough C, Malina RM, Klein RE. Height and body stature (such as height and sitting height) in our various racial groups; and (ii) to relate adult lung function to childhood respiratory health. A requirement of the studies which could be carried out in different centres would be that they be epidemiological (i.e. population-based) in concept and that SE indicators be recorded using standardized criteria in order that their relationships to (i) and (ii) above could be assessed. To minimize the effect of technical factors, it would be essential to standardize the methodology for recording respiratory histories, for measuring lung function and for analysing data. To develop suitable SE indicators, an essential preliminary to such studies and the key to their success, input from all sources including the social sciences should be sought.

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