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.

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-
TABLE I. DISTRIBUTION OF THE SOUTH AFRICAN WORK FORCE BY OCCUPATION IN 1977*  

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>White % distribution by race</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>29.1</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>29.2</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 Simkins and Hindson.

sidered under two general headings: (i) between-individual (the focus of clinical assessment); and (ii) between-population (the focus of epidemiological studies). Technical factors (i.e. measurement error) may contribute to both between-individual and between-population differences. Though responsible for a relatively small proportion of the variation, technical factors are important since they are susceptible to control by standardization of methodology and/or stringent calibration procedures. In good laboratories they account for approximately 3% of between-individual variation for the less complex tests such as forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1), and for a higher percentage in tests more complex for the subject and/or the operator.

In populations free of disease, the proportions of between-individual variation attributable to sex, race and age have been estimated at 30%, 10% and 8% respectively and to stature (height and mass) at 22%. Of the remaining 27% (excluding the 3% due to technical factors), about 10% can be attributed to smoking, leaving approximately 17% unexplained (residual variation). Included in the latter are genetic characteristics (e.g. α1-antitrypsin deficiency), past health experiences (e.g. childhood illnesses), environmental exposures related to home conditions (including passive smoking exposure) and to the work environment, in addition to socio-economic factors, the focus of this study, and probably other as yet unidentified factors.

All the above factors can, of course, contribute to between-population differences, the consequence of factors governing selection into and out of any population(s) chosen for an epidemiological study. For example, populations selected for comparison on the basis of occupational exposure or not are unlikely to be matched for some or all of the other sources of between-individual variation listed above, such as age, height and smoking. These must therefore be taken into account before any observed between-population differences in such a study can be attributed to the occupational exposure in question.

SE factors — definition and measurement

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 indicators used to reflect SE factors in studies of general and/or respiratory ill-health include: (i) occupation (parental in the case of children); (ii) education (parental in the case of children); (iii) family income; (iv) housing conditions; and (v) residential area. In some studies census (residence) information has been used as a basis for stratification by SE status before sampling. The first three indicators listed above have been related separately to health indices, including lung function, in some studies. In others a composite index has been developed based on one or more of these indicators and its relationship to lung function examined.

Relationship of general ill-health to SE factors

The links 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 over the succeeding century in the UK and other industrialized countries such as the USA, social-class gradients in 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 developed 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
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 occupation as the indicator. The small 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 social gradients spanned, probably more 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 FEV, 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 FEV, 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 FEV, 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, FEV, and maximal mid-expiratory flow rate (MMEF) 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 10000 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>Stebbings (Maryland, USA)</td>
<td>1971</td>
<td>410 men (35–64)</td>
<td>SE score including education</td>
<td>FEV, PEFR</td>
<td>Strong negative relationships; only non-smoking men studied</td>
</tr>
<tr>
<td>Lebowitz (Arizona, USA)</td>
<td>1977</td>
<td>3485 men (20–74)</td>
<td>Income, education and occupation</td>
<td>FEV,</td>
<td>Negative relationships to income and education but not to SE score</td>
</tr>
<tr>
<td>Cohen et al. (Maryland, USA)</td>
<td>1977</td>
<td>2000 men (20–74)</td>
<td>Residence classified by census data</td>
<td>FEV, DCO</td>
<td>Abnormality rates greater in lowest compared to highest SE group</td>
</tr>
<tr>
<td>Higgins et al. (Michigan, USA)</td>
<td>1978</td>
<td>4699 men and women (20–74)</td>
<td>Income, education and occupation (1626 employed men)</td>
<td>FEV,</td>
<td>Negative relationships to all SE factors but all weaker than smoking</td>
</tr>
<tr>
<td>Rasmussen et al. (Denmark)</td>
<td>1978</td>
<td>218 men (40–69)</td>
<td>Residential history (years in unheated homes)</td>
<td>FEV,</td>
<td>Negative relationship to duration of residence in unheated homes</td>
</tr>
<tr>
<td>Kauffmann et al. (Paris)</td>
<td>1979</td>
<td>556 men (30–54 in 1960)</td>
<td>Occupation Annual decline in FEV</td>
<td></td>
<td>Influence of occupational category on decline only slightly less than that of smoking</td>
</tr>
</tbody>
</table>

PEFR = peak expiratory flow rate, FEV, = 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.28 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,29 lung function was, contrary to expectation, better in children living in traditional houses than in those in modern council homes. 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 1911,29 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,13 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.30 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.39 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 published4 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.4 Of interest is the opinion expressed by some USA researchers40 that it may be possible to unravel
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 lowered 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,1 a single set of reference values does not seem 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.

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