Challenges and Recommendations for the Study of Socioeconomic Factors and Air Pollution Health Effects

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Commentary

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Abstract

Persons with lower socioeconomic status (SES) may face higher risk from polluted air. This disproportionate burden may result from elevated exposure, due to proximity to roadways or indoor air pollution from burning of biomass, and from differences in nutrition and access to health care, among other factors. Several studies have explored this topic, however, there remain many unanswered questions. Research on how SES affects the relationship between air pollution and health faces challenges including the choice and interpretation of SES indicators; distinguishing indicators that describe the present state and those that describe historical conditions; the correlation between SES indicators and other variables; differential diagnosis and use of health care services based on SES; and varying perceptions of health. This paper summarizes these and other challenges and provides recommendations for how to move this research forward. Recommendations relate to what geographical locations, health outcomes, and pollutants should be studied; community involvement; choice of socioeconomic indicators; and policy concerns. The conclusions presented here are intended to encourage collaborations to better understand and reduce disparities in environmental health.

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1. Introduction

While the relationship between socioeconomic conditions and air pollution as determinants of health has been considered and studied for decades, at least as early as the environmental justice movement, it is not fully understood. Collecting appropriate data, improving methods for assessing socioeconomic status (SES), and encouraging the application of uniform and sound methodology could enhance the study of this topic. To help address these research needs an international symposium was held to: (1) discuss policy needs and motivations; (2) identify gaps in currently available data; (3) share current research results and theoretical approaches; and (4) identify future directions for the study of socioeconomic conditions and air pollution as determinants of health. The meeting was held on September 23, 2003 in Perth, Australia, in conjunction with the 15th Conference of the International Society for Environmental Epidemiology (ISEE). The symposium was attended by over 90 participants including professors, public health officials, physicians, researchers, economists, company managers, and doctoral students from academic, government, research, and policy institu-
tions. Participants came from about 20 countries, including Guatemala, Brazil, Singapore, Chile, the United Kingdom, Australia, Taiwan, South Africa, Italy, Ghana, and Germany.

The issues of air pollution exposure and socioeconomic disadvantage are of special concern to rapidly developing regions, which often have widespread poverty in conjunction with the high air pollution levels that typically accompany industrial and economic growth. The proper evaluation of the health effects associated with air pollution and socioeconomic factors is of paramount importance in establishing the real costs of development and lack of air pollution control policies, and the distribution of those costs among segments of society. Therefore, the attendance of researchers from many countries of the developing world was crucial for providing realistic suggestions on research approaches, identifying challenges related to data collection and quality, and describing policy-relevant topics.

The symposium builds on several previous initiatives. The American Lung Association (ALA) held a workshop in 1999 to discuss air pollution and health inequities in U.S. cities, with respect to the disparities between the air pollution health consequences for the general population versus those for urban populations with high proportions of pollution and socioeconomic factors is of paramount importance in establishing the real costs of development and lack of air pollution control policies, and the distribution of those costs among segments of society. Therefore, the attendance of researchers from many countries of the developing world was crucial for providing realistic suggestions on research approaches, identifying challenges related to data collection and quality, and describing policy-relevant topics.

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For the purposes of the workshop, the term socioeconomic status was used in a broad sense, generally reflecting the concept of a person’s relative position in a stratified society. A rich tradition in sociology and philosophy is concerned with societal stratification and its consequences. Detailed discussion of these traditions, as well as the variety of ways SES can be measured, is found in Lynch and Kaplan (2000). Discussions in the ISEE 2003 workshop were not aimed at reaching a consensus on the definition of SES, but rather on discussing issues and challenges related to the research and the political, social and economic context in which such research is conducted and results applied. Therefore, the term SES in this paper should be understood to reflect that researchers in attendance were interested in using data on both personal characteristics (educational attainment, income, race/ethnicity, occupation) as well as characteristics of geographic places (housing features, neighborhood characteristics) to help them understand better the consequences of environmental exposures in stratified societies.

Although the conference focused on SES, participants highlighted the importance of also considering race and ethnicity. Race and ethnicity are often highly correlated with socioeconomic factors, such as educational opportunity or income. Further, race and ethnicity can also affect environmental burdens. Racial minorities and lower income populations may be exposed to higher air pollution levels than white or richer populations (Apelberg et al., 2005; Brown, 1995; Finkelstein et al., 2005; Sexton et al., 1993; Thurston et al., 1992) and are more likely to reside near hazardous facilities (Faber and Krieg, 2002; Morello-Frosch et al., 2002). Both income and race appear to play a role in the distribution of environmental health burdens, and the U.S. Environmental Protection Agency’s definition of “environmental justice” considers race, ethnicity, and income (USEPA, 2000, 2005). In addition, discrimination, displacement, and segregation are experienced differently by people according to their race and ethnicity. The experience of the Aboriginal peoples of Australia, the host country to the ISEE conference, is an important example. Though we recognize that SES is properly used as a concept distinct from race, ethnicity, and/or immigrant status, information on both was of interest to workshop participants, and is necessary for improved research to understand and eliminate health disparities (Ver Ploeg and Perrin, 2004). In a specific study, it is important for researchers to carefully describe and provide the rationale for their use of information on a person’s race or ethnicity, education, neighborhood, or other data used to categorize and compare individuals.

In the context of air pollution research, individual socioeconomic indicators often represent underlying characteristics that affect susceptibility, exposure, or disease diagnosis and treatment. Group-level information can reflect characteristics of neighborhoods and groups of people that can influence health and quality of life. SES, measured in these ways, may influence the relationship between air pollution and health through several pathways. Firstly, persons in lower socioeconomic conditions have poorer health in general, which could make them more susceptible to the damaging effects of air pollution. Secondly, those in lower socioeconomic circumstances may experience greater exposure to air pollutants, as they may live closer to roadways and polluting industrial facilities and have larger occupational exposure. Thirdly, they may have less access to health care than other populations, creating an exacerbation of any health response. This combination of increased susceptibility and exposure suggests that SES indicators may be useful for
characterizing populations that could face disproportionate burdens from the environmental health danger of air pollution.

Several studies address relationships among socioeconomic factors, air pollution, and health (e.g., Gouveia and Fletcher, 2000; Jerrett et al., 2004, 2005; Martins et al., 2004; O’Neill et al., 2004; Perlin et al., 2001; Wojtyniak et al., 2001). Research has shown differential exposure from traffic-related air pollution with respect to SES (Gunier et al., 2003), greater exposure to indoor air pollutants in economically developing countries based on income (Smith et al., 2000), and in some cases greater occupational exposure to air pollutants for those in lower income brackets (e.g., Rotko et al., 2000). In addition to exposure, baseline health status and health-related behaviors differ by SES; for example, smoking (CDC, 2005; Watson et al., 2003) and physical activity (Giles-Corti and Donovan, 2002). A discussion of hypotheses and research methods relevant to the study of air pollution, SES and health, as well as a summary of studies of socioeconomic factors and particulate matter are given in O’Neill et al. (2003).

2. Challenges and recommendations

This workshop provided researchers and policy-makers with an opportunity to explore how SES affects the relationship between air pollution and health in terms of research methods, data needs, policy considerations, and future directions. Symposium participants were divided into four working groups, each of which discussed separate issues and presented their conclusions to the entire group. Questions posed to the working groups included: what geographical areas would be useful to study and why? Which health outcomes are we interested in? Which are most practical to study? Which have the biggest potential to influence public policy? A full list of the questions is posted online at the workshop website (http://www.airimpacts.org/isee/). The following describes several key conclusions and recommendations resulting from this symposium.

2.1. SES and research design

2.1.1. Place- and context-specific variation in the meaning of SES

A crucial research issue is the choice and interpretation of SES indicators. Local, regional, national, and international variations in political and economic culture mean that SES variables will have different meanings in various contexts. Deciding what SES indicator should be used to identify susceptible populations is as important a research consideration as determining exposure to air pollution, and bias or measurement error. Common indicators of SES, such as education, income, or income inequality, should be used for multiple studies where feasible to aid comparisons, and in all cases, the method by which SES was determined should be clear.

Perceived SES may also differ by actual SES and by region. In other words, people may actually be better or worse off than they perceive themselves to be. For example, in one study, working class adolescents were more likely than upper middle class teens to misclassify their socioeconomic status (Goodman et al., 2000). Thus, an understanding of how SES itself affects self-perceptions of SES is an important consideration.

2.1.2. Temporal aspects of SES

Participants discussed many variables used to classify people in terms of SES (broadly defined), including poverty levels, social networks, educational attainment, social mobility, access to health services, insurance, housing characteristics and location, crowding, occupation, income, immigration status, and transportation use. These variables are often highly correlated (Fukuda et al., 2004; Lahelma et al., 2004). Some indicators define the current state (e.g., present-day income) and others provide historical information (e.g., income over the past 10 years). As in air pollution research, cross-sectional or shorter-term data are generally more widely available, but it is increasingly recognized that SES over the lifecourse is an important determinant of health.

2.1.3. Correlation between SES indicators and other variables

SES may be correlated to exposure to air pollution. For instance, poorer persons may reside closer to roadways and or have higher occupational exposure. This is but one of the potential connections between air pollution, SES, and health. However, SES variables may also be connected with other traits, such as age. The distinct contributions of these factors to defining vulnerability may not be discernible, but design and analysis methods can help address these correlations. For example, different health effects by SES could be studied only among elderly people so that age is less likely to confound observed differences.

2.1.4. Identifying characteristics of interest

Because many indicators of SES are available, symposium participants recommended choosing suitable SES indicators based on the potential policy action the research is designed to inform. If a community has plans for an intervention or legal action that pertains to particular locations (e.g., diesel bus stops) or health-promoting behaviors (e.g., access to parks or fresh fruits and vegetables), using data that capture these characteristics (e.g., proximity to bus stop, parks, or stores; income level, or car ownership) would be important.

2.2. Health outcomes

2.2.1. A wide range of health outcomes

A variety of health effects could be considered for the study of SES and air pollution, from more common, less severe outcomes, such as respiratory symptoms to more rare
and severe outcomes, such as death. Advantages of using mortality for this type of research are that it can be defined unambiguously, is of extreme health importance, and has large economic and social costs, making it of interest to policy-makers. Recent studies have found that those with lower education are at the greatest risk of air pollution-related mortality (HEI, 2000; Hoek et al., 2002). Because different pollutants may have varying effects on specific causes, studies of cause-specific mortality can provide insights into biological mechanisms, although all-cause mortality will provide greater statistical power. As the background rates of mortality and other diseases are elevated in the lower SES groups, it may be more difficult to detect the signal of air pollution effects. Other health outcomes may be difficult to study in low SES populations because of less access to and less seeking of health care, reporting bias, and interpretation of questionnaires.

2.2.2. Differential diagnosis and/or use of health care services

Some subgroups of the population may be more likely to use emergency rooms as health care rather than physicians’ clinics (Padgett and Brodsky, 1992). For example, immigrants are more likely to use emergency rooms than native-born residents in Copenhagen (Norredam et al., 2004), and lower-income elderly African Americans were found to have higher frequency of emergency room visits corresponding with lower access to physician services (Bazzargan et al., 1998). Hence, emergency room visits for respiratory or cardiovascular disease may be appropriate outcomes for these populations. In-depth community studies may be necessary to identify health responses in cases where some persons may not seek or have access to health care for particular health endpoints.

2.2.3. Access to health data

The availability of health data may vary by SES. For example, in Brazil, morbidity data are available from the public health system, which attends to the poorest fraction of society (Braga et al., 2001). The private medical care system does not provide access to medical records at either the individual or aggregate level. While mortality records encompass information from the whole population, existing morbidity data are limited, impairing effects estimates by SES. Other regions may have missing or inaccurate mortality data as well. In communities that face limited health data, alternative sources of health information need to be defined to allow a broad range of investigation.

2.2.4. Perception of health and health care

Perceptions of health can vary with SES, which should be considered when using questionnaire data. In fact SES status itself may have an impact on self-rated health (Nishi et al., 2004), and the relationship between SES and self-perception of health can vary by region (e.g., Jelsma and Ferguson, 2004; Reijneveld and Stronks, 2001; Szafarski and Cubbins, 2004). Further, health responses in questionnaires may have different meanings across regions. In the Central European Study of Air Pollution and Respiratory Health (CESAR) study, researchers noted different symptom prevalence among the European countries, which could be the result of actual prevalence differences, or the result of differences in language and the interpretation of questionnaires. For example, in Germany, there could be regional differences in interpretation of terms like “wheeze.” Some subsets of the population, such as immigrants, may be wary to report health problems or participate in studies. The perception of feeling ill also differs across social class, with people who are less well off possibly having lower expectations of health. Objective measures of health, such as pulmonary function and cardiovascular outcomes, may be somewhat better indicators of health status than subjective or self-reported measures.

2.3. Air pollutants and sources

 Numerous air pollutants have been associated with adverse human health effects and many share similar sources (Holgate et al., 1999). Thus, the choice of what pollutants to study is not trivial. Participants discussed whether to research individual pollutants (e.g., particulate matter, ozone), pollution mixtures involving multiple contaminants (e.g., sulfur dioxide and ozone together), or whole classes of pollution sources (e.g., motor vehicle, stoves). This choice will depend on the dominant sources and exposure pathways for the study region, and what mitigation measures for controlling sources and exposures are available to decision-makers. For instance, environmental tobacco smoke and the burning of biomass for cooking and heating are significant sources of exposure, which may be related to SES. In India, indoor air pollution from biomass as a cooking source is a serious health threat, with associations between income level and the types of fuel and cooking stoves (Mishra, 2003). A study in Guatemala identified an association between the type of indoor fire and socioeconomic factors, such as possession of a radio and television and floor type (Bruce et al., 1998). Exposures to traffic emissions is a major issue in most countries, and a growing problem for rapidly developing nations. The relationship between transportation-related pollution and SES will differ by region, the nature of the transportation fleet (e.g., diesel versus gasoline-fueled engines), and the socioeconomic residential and working patterns that affect proximity to roadways. In other cases, industry will be the primary source of air pollution. Studies could begin by focusing on the emissions sources that are the major contributors to air pollution and/or those that are poorly understood. These include the cement industry and the petrochemical industry for some cities in Taiwan (Lin et al., 2001; Yang et al., 2002, 2003); transportation, electricity generation, industry, and home heating by wood and coal in Australia and New Zealand (Kjellstrom et al.,
2.4. Geographic areas

The choice of study region for research on socioeconomic factors, air pollution, and health is critical as it determines how the results can be interpreted and applied. Studies can be conducted at the local, regional, or national scale, and the choice of scale affects study design and the relevance to policy. Because conditions such as baseline population characteristics differ by region, results from one area may not be readily applied to another location. Symposium participants had several key recommendations regarding choice of geographic area.

2.4.1. Leverage existing research

Basing study designs on areas for which other research is already underway takes advantage of resources already in place, such as datasets, knowledge of local communities, and a relationship with the local population and government. Several examples of on-going relevant work on air pollution that could integrate socioeconomic factors are:

- the IES program with studies in Beijing, Shanghai, Seoul, Manila, Hyderabad, São Paulo, Buenos Aires, Santiago, and Mexico City (www.nrel.gov/environment/environmental_strategies.html);
- the meta-analysis of the Italian Studies on Short-term Effects of Air Pollution (MISA) (Biggeri et al., 2001);
- the Air Pollution and Health: a European American Approach (APHENA) project, which builds on the Air Pollution and Health: a European Approach (APHEA) (Atkinson et al., 2001; Samoli et al., 2001, 2003; Sunyer et al., 2003) and National Morbidity, Mortality, and Air Pollution Study (NMMAPS) projects (HEI, 2003; Samet et al., 2000a,b,c);
- the Health Effects Institute (HEI) Public Health and Air Pollution in Asia (PAPA) initiative (HEI, 2004).

2.4.2. Natural experiments

Studies encompassing changes in air pollution that take place quickly, such as changes in transportation during the 1996 Olympic Games in Atlanta (Friedman et al., 2001) or a ban on coal sales in Dublin (Clancy et al., 2002), can provide insight into how SES affects the relationship between air pollution and health. Future possibilities include the 2010 World Expo in Shanghai and the 2008 Olympics in Beijing, which are likely to have significant changes in air pollution concentrations. These occurrences offer unique opportunities to study public policy “interventions,” whether or not intended for the purpose of health improvements. Additionally, since the studies compare health outcomes before and after the event, the health impact is measured in the same population, which retains the same general population characteristics with regard to SES and other factors, thus controlling for some potential confounders, such as smoking.

2.5. Data needs

Participants noted several data-related challenges. For example, air pollution monitoring networks are typically designed for regulatory compliance, and may not be ideally located for health research or for evaluating SES factors. Regions without extensive data should not be overlooked, although there is a need for methodology to address data-poor areas, such as imputing missing data or using airport visibility data to estimate pollution levels (e.g., Vajjanapoom et al., 2001).

2.6. Research needs

In addition to the data needs described above, research needs include methods to compare results from different locations; approaches to study areas with limited data on SES, health outcome, and/or air pollution exposure; and methods for data collection in various communities and settings. A further research need is for statistical models to help analyze the relationships between SES, air pollution, and health. This issue is complex as the analysis of air pollution health effects and SES must take into account non-linearity, various lag structures, and confounders. The multi-dimensional characteristics of this issue could be addressed through hierarchical models that look at the relationship in multiple levels, and through structural and pathway models that account for a web of causation. The symposium participants acknowledged the multi-disciplinary aspects of this topic and recommended collaborating with social epidemiologists and health economists in designing research on SES and air pollution. Case studies were recommended as a way to explore research approaches and to demonstrate the relationships between SES, air pollution, and health.

2.7. Coordination and communication

A key recommendation was enhanced communication and coordination on several fronts. There should be better synchronization among research efforts including the addition of SES research to on-going investigations, which can make use of existing research structures, databases, and relationships with local communities. Further, there should be increased involvement of the community, local, regional, and national organizations at all stages, from study design through to implementation and results’ dissemination. Strengthening ties between the community and researchers can aid in multiple issues, such as recruitment of study participants, researchers’ understanding of subjects’ perception of questionnaires, and
community trust in the study results. Also, involvement at multiple organizational layers increases the probability of successful response strategies, which may come from different levels. Researchers should also coordinate with decision-makers to determine whether their interest lies in the health impacts of air pollution, SES, or both. Consideration should be given to what types of information are most useful to promote or support actions by policy-makers and citizens. For example, some may respond more to studies that include valuation and co-benefits. To encourage this communication, symposium participants recommended a follow-up workshop with researchers and policy-makers. In particular, many thought that a useful next step would include discussion of a series of in-depth case studies where specific local problems were addressed and research results affected policy.

2.8. Community involvement

A key feature of a successful study is involvement from the local government and community, which is necessary to ensure recruitment of study populations, researcher credibility, and an accurate understanding of local conditions, such as health care systems and local income levels. This is particularly important if the research is an intervention study. The collection of data in lower SES may involve low response rates due to community fears and language barriers. Risk perceptions and health expectations may also differ by SES.

Without local involvement, communities may perceive that they are being used for research. These “overstudied” communities want solutions, not more research results. As an example, local residents of the far over-drained and extensively researched Aral Sea jokingly commented that if every scientist brought a bucket of water, the sea would be full by now (Hidalgo, 1999).

Community involvement in research can help address residents’ concerns. Successful community participation requires involvement at all stages: design, implementation, and interpretation. Researchers should write about the tangible advantages from collaborations with communities and alternatives to the classic power relationship between researcher and subject, in order to encourage community participation by other research efforts. Such involvement provides multiple benefits including cooperation of participants; access to indigenous knowledge; enhanced dissemination and understanding of results and related health issues by the community; improved public perception of the health research community; and heightened interest in and application of results by local decision-makers. A strong relationship between the researchers and community can help illuminate the connections between risk factors and health outcomes for both the researchers and local residents (Smith, 1998). To succeed, community involvement should be formalized (Steiner et al., 2005) and regularly assessed (e.g., South et al., 2005).

2.9. Policy and decision-makers

2.9.1. Relationships to policy and other issues

This type of research delves into the social and political structures that generate or perpetuate an SES gradient that affects health, outside of the adverse impacts of air pollution. Therefore, this work must be conducted with a broader perspective of economics, society, and culture than would be required by more traditional air pollution and health research. These complex issues should not be examined in isolation, especially as SES and air pollution can be interconnected. For example, in China, the SES is generally rising and more people can afford vehicles, which increases emissions (Nehru et al., 1997). Increased access to electricity may raise air pollution levels through emissions from power plants, but also bring about changes in how food is kept and prepared, leading to improvements in health. Many air pollution control technologies, such as newer automobiles and more technologically advanced indoor cooking stoves, are expensive, creating additional connections between a community’s SES and exposure levels.

2.9.2. Interpretation of results

Studies of SES and air pollution are likely to be of significant interest to policy-makers and the public. However, the intended impact of the results may be ambiguous. If disadvantaged populations are more affected by air pollution, this raises the issue of how to address the disproportionate impact and the origin of this burden. A key issue for researchers is the degree to which these components (air pollution, health, and SES) matter separately to decision-makers and the public. For example, a response to results identifying disproportionate impacts from air pollution by income could be strategies to lower air pollutant concentrations, policies to raise the SES of populations, or both. Research results can be presented and interpreted for decision-makers in a way that informs development of interventions on both environmental and socio-economic fronts.

2.9.3. Involvement of multiple agencies

The regulatory structures and governmental agencies that address air pollution and poverty/development may be separate. For example, in the U.S. issues of air pollution, health, and socioeconomic concerns are addressed by numerous organizations, such as the Environmental Protection Agency (USEPA), the Department of Health and Human Services, the Centers for Disease Control and Prevention, and the Department of Transportation. Thus, addressing SES, air pollution, and health can involve multiple agencies, such as those relating to transportation, the environment, health, and energy. In order to get meaningful decision-making and allocation of resources, coordination between multiple organizations is required. National, regional, and community-level organizations should be included as they have different capacities for
providing solutions. Whereas larger organizations can enforce national policy, local agencies may be better equipped for other solutions, such as public education and change in the type of indoor cooking fuels.

3. Conclusions

In this international workshop, researchers and policymakers were provided with an opportunity to explore how SES affects the relationship between air pollution and health and make recommendations regarding research methods, data, policy considerations, and communication. This workshop was one of several recent activities that reflect increased recognition of the importance of both social and environmental determinants of health. The USEPA, for example, published a Framework for Cumulative Risk Assessment in 2003, which includes social stressors along the spectrum of determinants of health that would be important to consider in risk assessment (USEPA, 2003). The USEPA subsequently invited the National Environmental Justice Advisory Council (NEJAC) to recommend ways to implement concepts in the Framework to ensure environmental justice (NEJAC, 2004). These efforts by USEPA and NEJAC, previous workshops (ALA, 2001; Bell et al., 2002a,b; O’Neill et al., 2003), and a growing number of research studies highlight the rising concern regarding the relationship between air pollution and health with respect to SES.

By bringing together a group of international researchers to discuss common research goals, challenges, and findings, this workshop achieved the objectives of exchanging ideas on research; making recommendations related to research, interpretation, and policy; and providing new insights for the participants on future directions and collaborations. International and interdisciplinary collaboration on social and environmental determinants of health, as facilitated by workshops such as this one, is critical to better understand and to reduce the factors that unequally burden vulnerable members of society.

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References


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