International Conference on Environmental and Occupational Lung Diseases

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Poverty and lack of development are critical contributing factors to environmental hazards that affect the health of many hundreds of millions of people worldwide, particularly at the household level. Too often in too much of the world, however, the industrial and commercial development that helps reduce poverty has resulted in ambient environmental degradation and threats to human health as well. Workplace hazards are all too common everywhere. There is therefore a double need for research and action: *a*) to reduce the environmental health hazards of poverty and, *b*) to guide economic development in ways that produce healthy environments for the public and workers as well as economic well-being. Health is not only a goal in its own right but also a prerequisite to sustainable economic development.

Although other important diseases have significant environmental determinants, including malaria and diarrhea, the burden of respiratory diseases is large on a global basis and is a strong function of environmental conditions in all countries. Polluted air in the home, workplace, or ambient environment is responsible for serious health effects in both developed and developing countries. It varies from country to country depending on geography, climate, industrial patterns, cultural factors, fuel use, and government policy, for example. In addition, actual individual exposure to air pollutants may vary greatly depending on the location and activity of the individual. In addition to exposure patterns and the character of the pollutants, health impacts themselves depend further on age distribution, nutritional status, preexposure to other chemicals, background disease rates, genetic factors, and other population characteristics. In all, however, the absolute health impact of pollution is substantially greater in the developing world, although there are important variations by pollutant categories.

Given the worldwide importance of environmental and occupational respiratory disease at all levels of development, it is valuable to provide a global venue for sharing information among scientists and policy makers concerned with these environmental health concerns.

Conference Objectives

An international conference to address these issues was hosted by the Industrial Toxicology Research Centre (ITRC) 29 October–2 November 2000 in Lucknow, India. It was convened by the National Institute of Environmental Health Sciences (NIEHS); the U.S. Environmental Protection Agency (U.S. EPA); the U.S. Agency for International Development; the Institute for Global Health, University of California; the Center for Occupational and Environmental Health, University of California; the World Health Organization (WHO); the Centers for Disease Control and Prevention; the World Bank; the Council of Scientific and Industrial Research; and ITRC. About 175 participants from 27 countries attended.

The purpose of the conference was to bring together experts in the field of environmental and occupational respiratory diseases to focus attention on major health problems that affect millions of people around the globe and to stimulate research and development of appropriate public health responses in a fresh perspective. Accordingly, the conference was organized to facilitate sharing of information across four important spectra dealing with the problem.

Countries at different levels of development. Many hazards that have been encountered and dealt with in developed countries in the past are of vital concern to developing countries today. In addition, developed countries can still benefit from studies on pollutants of concern performed in relatively high-exposure settings in developing countries.

Household, workplace, and ambient exposure settings. In particular, results from studies of the high exposures traditionally found in workplaces are useful in the efforts to understand and control exposures elsewhere, which tend to be smaller for each individual but involve larger populations.

Infectious, chronic, and malignant diseases. There can be important shared mechanisms leading to different types of respiratory end points from pollutant exposures. In addition, of course, there is value in understanding how individual disease patterns may shift as exposures and populations change.

Disciplines of toxicology, epidemiology, and risk/policy analysis. To effectively understand and address the scientific issues in ways that lead to effective interventions, there should be good communication across disciplinary boundaries.

The specific aims of the conference were to

- Characterize current trends in environmental and occupational respiratory diseases in various regions of the world, with particular emphasis on developing countries
- Review the extent and limits of scientific data on the most important environmental and occupational air contaminants and the extent to which these agents contribute to the development of preventable respiratory diseases
- Review the contribution of predisposing conditions such as nutritional status, infectious diseases, and climate to the development of environmental pulmonary diseases
- Identify and characterize subpopulations (e.g., children, women, and the elderly) with heightened susceptibility to environmental pulmonary disease
- Review the "state" of knowledge of toxicology, epidemiology, and risk assessment related to environmental and occupational diseases and to identify critical research gaps in these disciplines.

Conference Themes: Exposure Settings

Household Exposures

A large and growing body of scientific evidence indicates that household air pollution exposures contribute substantially to the burden of respiratory diseases. The most important

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Received 22 January 2001; accepted 21 February 2001.

source of indoor air pollution in developing countries is the unvented burning of coal and biomass, such as wood, dung, and crop residues. The potentially exposed population is large in that nearly half the world's population cooks daily with such fuels. Such fuels dominate in rural areas, but also are used in many urban slums, which make up one-third of the city population in many developing countries. Burning biomass fuels in simple household stoves produces large amounts of respirable particles, carbon monoxide, toxic hydrocarbons, polycyclic aromatics, carbonyl compounds, and other air pollutants in the confined space of the home. Depending on fuel quality, coal smoke can contain, in addition, the hazardous compounds of sulfur, arsenic, and fluorine. In these circumstances, exposure to pollutants is often far higher indoors than outdoors.

Epidemiologic studies in households in developing countries have strongly linked exposure to indoor air pollution from solid fuels to acute lower respiratory infections (ALRI) in children, chronic obstructive lung diseases and associated heart conditions, and lung cancer. Growing evidence also implicates asthma and tuberculosis (TB) as well as the nonrespiratory conditions of cataracts and adverse pregnancy outcomes (stillbirth, low birth weight, and infant death).

Of these, ALRI appears to have the greatest health impact in terms of the number of people affected and the number of life years lost. Overall, studies indicate that exposure to wood smoke from cooking fires in poorly ventilated conditions may increase the risk of a young child contracting a serious respiratory infection from two to six times. Adults suffer the ill effects of severe indoor pollution as well. Strong links have been found between chronic lung diseases in women and exposure to smoke from open cooking stoves. Transition up the energy ladder from dirty to clean fuels will greatly reduce the threat from indoor air pollution in developing countries.

In developed countries, many epidemiologic studies have associated environmental tobacco smoke (ETS) exposure with several disease outcomes. As smoking rates increase in developing countries, such risks are likely to increase in importance. Also in developed countries, indoor airborne radon levels have been associated with increased lung cancer risk, but few studies have been done in developing countries.

The conference participants recognized the need for intervention studies to determine the degree to which household indoor air pollution exposures can be lowered and to measure changes in respiratory health risk that result. Although technically feasible, good studies will require thoughtful design, sufficient funding, and considerable patience. Respiratory disease etiology is highly multifactorial in nature, and indoor air pollution in any given location is only one of an array of respiratory risk factors. It will therefore be essential to conduct intervention studies in multiple locations. Participants suggested the need for promoting dialogue among policy makers, researchers, nongovernmental agencies, and research sponsors to tackle household exposure problems. Longitudinal studies should be conducted to quantify the long-term effects of air pollution on children's health and the related burden of disease to evaluate control measures, and also to develop feasible, acceptable, and effective interventions to reduce household air pollution exposures.

P.K. Seth, Director of the ITRC, welcoming the attendees at the opening ceremonies of the International Conference on Environmental and Occupational Lung Diseases. Left to right: P.K. Seth (at the podium), S.H. Zaidi (Founder Director ITRC), Kenneth Olden (NIEHS), N.K. Ganguly (Indian Council of Medical Research, New Dehli, India), Kirk R. Smith (University of California, Berkeley), Paul Nettesheim (NIEHS), and Qamar Rahman (ITRC).

Outdoor Exposures and Risks

Contemporary understanding of the health effects of outdoor air pollution dates to approximately the middle of the twentieth century. The "killer fog" in the small town of Donora, Pennsylvania, and the particularly virulent London "smog" of 1952, in which some 4,000 people died, were associated with widespread use of dirty fuels and were catalysts for government efforts to tackle urban air pollution. Since then, many nations, including India, have adopted ambient air quality standards to safeguard the public against the most common and damaging pollutants. These include sulfur dioxide, suspended particulate matter, ground-level ozone, nitrogen dioxide, carbon monoxide, and lead—all of which are tied directly or indirectly to the combustion of fossil fuels. Although substantial investments in pollution control in some industrialized countries have substantially lowered the levels of these pollutants in most cities, air quality is still a major concern throughout the industrialized world.

Urban air pollution has worsened in most large cities in the developing world, a situation driven by population growth, industrialization, and increased vehicle use. Despite pollution control effects, air quality has approached the dangerous levels recorded in London in the 1950s in a number of megacities, such as Beijing, China; Delhi, India; Jakarta, Indonesia; and Mexico City, Mexico. WHO estimates that as many as 1.4 billion urban residents breathe air that exceeds the WHO air guidelines. The health impacts of urban air pollution seem likely to be greater in some of the rapidly developing countries where pollution levels are higher. The World Bank has estimated that exposure to particulate levels that exceed the WHO health standard accounts for roughly 2–5 % of all deaths in urban areas in the developing world. Health effects span a wide range of severity from coughing and bronchitis to heart disease and lung cancer. Vulnerable groups include infants, the elderly, and those suffering from chronic respiratory conditions including asthma, bronchitis, or emphysema.

Respirable particulates are known to cause respiratory diseases; however, the physiologic mechanisms are still not certain. Evidence from a number of laboratories now indicates that particulates increase lung immune activity that may be either a cause or a reflection of events in the lung. It has been suggested, however, that therapeutic

interventions targeting macrophage immune function may be useful in decreasing adverse effects of particulate exposures.

Particulate air pollution is a complex mixture of small and large particles of varying origin and chemical composition. Larger particles, ranging from approximately 2.5–100 µm in diameter, usually comprise smoke and dust from industrial processes, agriculture, construction, and road traffic, as well as plant pollen and other natural sources. Smaller particles—those < 2.5 µm in diameter—generally come from combustion of fuels. These particles include soot from vehicle exhaust, which is often coated with various chemical contaminants or metals, and fine sulfate and nitrate aerosols that form when SO_2 and nitrogen oxides condense in the atmosphere. The largest source of fine particles is coal-fired power plants, but automobile and diesel exhaust are also prime contributors, especially along busy transportation corridors. Small particles are likely to be most dangerous because they can be inhaled deeply into the lungs. The constituents in small particulates tend to be more chemically active; they may also be acidic and therefore more damaging.

SO_2 is emitted largely from burning coal, high-sulfur oil, and diesel fuel. Although ambient concentrations of SO_2 have declined in many cities in Western Europe and North America, they remain higher (often by a factor of 5–10) in a number of cities in Eastern Europe, Asia, and South America, where residential or industrial coal use is still prevalent and diesel traffic is heavy. SO_2 affects people quickly, usually within the first few minutes of exposure. Epidemiologic studies indicate that SO_2 exposure can lead to acute health effects typical of particulate pollution.

Ground level ozone is the major component of the photochemical smog that blankets many urban areas. It is not emitted directly but is formed when nitrogen oxides from fuel combustion react with volatile organic compounds (VOCs) such as unburned gasoline or paint solvents in the atmosphere. Sunlight and heat stimulate ozone formation, so peak ozone levels generally occur in the summer. Many cities in developing countries also suffer from high ozone levels, although few monitoring data exist. Ozone, a powerful oxidant, can react with biological tissue. Breathing ozone concentration of 0.012 ppm—levels typical in many cities—can irritate the respiratory tract and impair lung function, causing coughing, shortness of breath, and chest pain.

Paul Nettesheim presenting the conference photograph to R.A. Mashelkar, Director General, Council for Scientific and Industrial Research.

Programs that stand to confer benefit in multiple sectors simultaneously, such as air pollution abatement programs that simultaneously reduce greenhouse gas emissions and reduce risk of (respiratory) disease, should be implemented. The challenge for researchers is to identify country-specific research. New approaches such as multilevel and multicountry studies and findings in developed countries should be made available to less developed countries for controlling air pollution.

Occupational Exposures

The gravest occupational lung disease, pneumoconiosis, caused by coal and other dusts, was first identified at the end of the nineteenth century. Its gravity depends on the type of dust exposure, including fineness, concentration, and duration, and the victim's preexisting health. Silicosis caused by inhalation of dust containing free silica or silicon dioxide was first reported in 1947 in India in the Kolar gold mines and has since been reported in various other mines and industries: coal, mica, silver, lead, zinc, and manganese mines; pottery and ceramics; sand blasting; metal grinding; building and construction work; rock mining; iron and steel industry; and several others. The slate pencil factories of Mandsaur in India are a case in point where most of the workers suffer from silicosis. In a survey by the ITRC (*1*), the prevalence of silicosis in agate workers in Khambhat, India, was found to be 18%.

There is no question that asbestosis caused by the inhalation of asbestos fibers can lead to mesothelioma. Large populations of workers worldwide have or will develop this deadly disease because of past exposures to asbestos in shipbuilding and other industries. In a recent ITRC study (*2*), it was reported that workers exposed to kerosene smoke at home and to asbestos at work are at higher risk for early development of asbestos-induced diseases than those exposed to asbestos alone. In India and elsewhere in developing countries, the use of sheets, pipelines, and other asbestos cement products is now increasing. More information is urgently needed about the extent of hazards represented by these products as they age and weather.

Byssinosis is the scourge of textile workers and is caused by cotton dust during processing. A variant of this fiber-related disease is bagassosis, which occurs when sugar mill workers inhale the dust from bagasse or cane waste, which is used for making paper and other materials. In much the same manner, workers engaged in hemp, flax, and sisal units suffer allergic reactions from dust exposures.

Kenneth Olden receiving a conference memento from N.K. Ganguly.

TB is another occupational health hazard. The most vulnerable are those working in quarries, mines, textiles, and other industries where the work exposes individuals to dust. People, especially women, who work in power loom and tobacco-processing industries constantly inhale fibers and dust. Combined with poverty, squalor, and congestion, these people rapidly develop pneumoconiosis, which eventually progresses to TB.

Occupational and household fuel smoke is a known risk factor for a number of respiratory diseases, and there also are indications of possible synergisms between exposures to fuel smoke at home and to fibers and other contaminants at work. More work is needed to understand the role of such combinations of environmental and occupational risk factors in the manifestation of disease.

Plastic recycling involves hazardous processes: melting, granulating, and blowing the plastic waste. Most of these factories are household based, often in poorly ventilated conditions. Brown toxic fumes from the process lead to respiratory disorders for workers and residents.

Workers in many traditional handcraft industries (carpet weaving, brassware, precious stone polishing, glass bangles) unfortunately also suffer from lung diseases to some extent, especially women and children.

Conference participants suggested that respiratory disease risk can be reduced by developing and implementing a program targeted to cessation and prevention of tobacco smoking and to reduction (elimination) of exposure to ETS (passive smoking).

Conference Themes: Diseases

COPD and Asthma

Chronic obstructive pulmonary disease (COPD) is anticipated to become the third leading cause of death in 2020 worldwide. Mortality rates for bronchial asthma have shown a tendency to increase in the last

decade, and the annual toll now exceeds 180,000 (*3*). In general, COPD is currently more frequent in industrialized countries, where it is a strong function of past smoking rates. The relationship of smoking and COPD has been observed in many studies conducted the world over. An apparent exception is in China, where COPD rates are quite high in spite of shorter smoking exposures. COPD is also strongly associated with age; thus prevalence and incidence are increasing with the aging of populations.

Prenatal exposure to cigarette smoke is also a potential risk factor for adult COPD, as is a history of childhood respiratory infection induced by a range of causes including indoor and outdoor air pollution. Chronic exposure to fumes, chemical substances, and dust in the workplace represents one of the main factors for development of COPD and asthma. Grain dust, coal, and other mineral dusts; isocynates; heavy metal adhesives; and welding fumes are a few relevant causes of COPD and asthma among workers in mining, quarrying, construction, agriculture, textile manufacture, and wood and paper industries.

An individual's susceptibility to environmentally mediated disease may also arise from genetic causes. Asthma is a complex genetic disorder that is caused by a number of unique gene–gene and gene–environment interactions. The search for asthma susceptibility genes has been complicated; it has been suggested that environmental challenges can be used to narrow the phenotype of asthma, thus allowing investigation of unique gene–environment interactions that are involved in the development of biologically specific forms of asthma.

The conference participants suggested a need for longitudinal epidemiologic surveys in population samples from different geographic areas for a more thorough comprehension of natural history of COPD and asthma.

Infectious Respiratory Diseases

ALRI continues to be deadly in developing countries despite the availability of modern therapeutic agents, largely because of lack of access to medical care and such predisposing factors as undernutrition, micronutrient deficiency, poor housing, and dirty fuels. Lower respiratory tract infection ranks number 3 among the causes of death worldwide, but is

Statements and Recommendations

Conference Summary

The 175 scientists attending the conference from 27 countries noted that

- Environmental and occupational respiratory diseases account for a significant portion of preventable illnesses and premature deaths in the world.
- These respiratory diseases result from common exposures to contaminants in households, workplaces, and outdoor environments.
- All countries share these problems, but the burden is greatest in developing countries such as India.
- The most important of the respiratory diseases known to have major environmental risk factors include pneumonia, chronic obstructive lung disease, TB, asthma, lung cancer, and various occupational lung diseases.
- Because there are no effective cures for most of these diseases, it is only through prevention that their burden on society can be lessened.
- Environmental lung diseases most affect the least advantaged and most vulnerable groups in society, including poor women and children, the malnourished, disenfranchised workers, and slum dwellers.

Resolutions

After its deliberations, the participants made the following resolutions:

- Although more research is needed to understand the details of how polluted environments affect health in developing countries, enough is known from studies elsewhere to warrant immediate action to reduce exposures to many specific pollutants. There is little evidence to suggest that the health effects of pollutant exposures vary substantially in different parts of the world.
- Scientific research should focus on exposures and health impacts that affect vulnerable groups such as young children, pregnant women, and those with poor nutrition, for whom available data may not be adequate to assess risk.
- Further health assessment efforts should be undertaken to show that environmental and occupational health interventions can be cost-effective ways to improve health and advance economic growth.
- Agencies responsible for public health, worker health, environmental and industrial engineering, environmental monitoring, biomedical research, health policy, and respiratory medicine should develop coordinated activities to effectively deal with the polluted environments that produce these diseases.
- National efforts to control TB and other infectious diseases can particularly benefit from such intersectoral collaboration.
- Effective and sustainable interventions for cleaning up polluted environments will be best achieved by engaging community and labor groups and the media, as well as government agencies and scientific organizations. Binational and multinational collaboration can also be important.
- India and other developing countries should consider creating national centers of excellence to assess these problems and develop solutions. In addition to environmental health scientists and physicians, such centers should include behavioral scientists, engineers, economists, and policy analysts so that effective interventions can be designed and implemented.

— An immediate priority for these centers should be to foster the development of the high-quality training programs needed to bolster the ranks of scientists and others required to address the widespread problems posed by polluted environments in developing countries.

— Such institutions should develop collaborative relations with similar institutions throughout the world so that research, training, and implementation efforts can take advantage of the best available knowledge. Advanced techniques of research, including genetic sequencing, biomarkers, and sophisticated toxicologic methods, show promise to help better understand some of the worst problems created by high environmental exposures, but should be applied only where needed since much improvement can be achieved with current methods.

— These institutions should also play an active role in promoting environmental and occupational health among policy makers, the medical and scientific communities, the industrial/commercial sector, and the general population.

Priorities for Action

Among the global priorities for action and research identified by the participants, a number are of particular importance in India.

Workplace

- Agricultural work is the largest global occupation, with many known respiratory hazards. With risks even greater than those of pesticides, various agricultural dusts produce significant respiratory disease among agricultural workers in developing and developed countries. Efforts are needed to develop systems to monitor and prevent the occurrence of these diseases.
- Silicosis, TB, asbestosis, and other debilitating and often fatal lung diseases are a significant hazard of working in various mining, rock

highest in numbers of life years lost because of its importance in young children. Of the 4.3 million deaths due to ALRI worldwide in 1990, 3.9 million occurred in developing countries (*4*). Acute respiratory infection is the most common form of morbidity in children worldwide, but rarely proceeds to mortality in developed countries. In the developing countries, however, acute respiratory infection is roughly equal to diarrhea as the most important cause of mortality in young children.

Nonbiological agents form one of the important risk factors for the development of acute respiratory tract infection. The multifactorial gene–environment interaction is more relevant in children because large changes in gene expression occur during development and also during changing lifestyle exposures. Other factors such as age, disease state, diet or dietary supplementation, demographic characteristics, and socioeconomic conditions are also important to an individual's susceptibility to environmentally mediated disease.

There is accumulating evidence that exposure to air pollution, both indoor and outdoor, may be a risk factor for TB, which causes more adult deaths worldwide than any other single infectious disease. The occupational evidence is clear; for example, incidence of bronchial asthma and TB are high among brass industry workers in India. Laboratory and field-based studies should contribute to the understanding of the role of antioxidant genes of *Mycobacterium tuberculosis* in TB pathogenesis and the role of environmental air-reactive oxygen and nitrogen intermediates in affecting the biologic characteristics of *M. tuberculosis.*

The challenge for researchers interested in environmentally mediated disease or risk assessment is to understand the importance of socioeconomic and genetic factors in the incidence of lung cardiopulmonary diseases. We may gain this understanding by relating laboratory, clinical, and epidemiologic findings.

Reducing the burden of respiratory tract infection is an important public health challenge. This can be attained by controlling indoor and outdoor air pollution, reducing exposure to active and passive tobacco smoke, and improving nutritional status and other living standards.

quarrying, and other dusty jobs. Surveillance and prevention efforts are needed to protect the millions of workers at risk.
- Extremely polluted conditions involving dusts, chemicals, and smoke unfortunately prevail in many of the thousands of small industries making up the informal sector in India and elsewhere. More effort is needed to inventory these conditions and protect the workers most at risk.

Households

- As in other poor countries, the traditional fuels, such as cow dung, wood, and crop residues, used in 80% of Indian households produce large quantities of pollutants known to seriously affect health. Because they are often burned in poorly ventilated conditions, such fuels seem to be responsible for substantial ill health in India.
- Efforts to promote cleaner fuels, improved stoves, and better ventilation should have high priority wherever they can be effectively introduced. Where appropriate, the lessons learned in one country and region should be effectively applied in others.
- Coordinated multisite research efforts are needed to specify and quantify the health effects of exposures to this ancient pollution source. Although other diseases are also thought to be associated with these exposures, the priority should be given to childhood pneumonia, TB, and adverse pregnancy outcomes such as low birth weight, which is a risk factor for a range of diseases later in life.

Outdoors

- The worst urban air pollution is found in developing countries, including some Indian cities. Although not enough research has been done to quantify effects, the large and growing number of highly consistent results from developed countries give high confidence that such pollution levels are responsible for much disease and premature death in India and other developing countries.
- Effectively abating air pollution will require dealing with modern sources such as vehicles, power plants, and factories and addressing waste burning, informal sector activities, and household fuels.
- The most pressing immediate need is to develop the reliable and sufficiently widespread environmental and health monitoring systems required to effectively target actions to reduce outdoor pollution and evaluate their effectiveness.

Important Issues

The conference also called attention to four issues of particular importance throughout the world:

- Alarmingly, active and passive smoking of tobacco in all its forms, which is the most important cause of respiratory disease in the world today, is increasing in many countries. Every effort should be taken to reverse this trend and reduce smoking rates to the lowest possible levels. No conceivable economic benefit from the production and sale of tobacco justifies the heavy health burden that tobacco smoking imposes.
- The evidence that exposure to asbestos fibers is an extreme risk to health is overwhelming. The world community should move to implement measures to rapidly decrease exposures to this hazardous substance, with a target of zero exposure.
- Because devastating occupational diseases such as asbestosis, silicosis, and occupational lung cancers appear years after the first exposure, current occupational exposures will cause disease and death for many years to come. It is critical to immediately control exposures through substitution, process changes, and engineering controls to head off severe future problems.
- Governments should work with industries to allow medical and environmental researchers access to workplaces so that working conditions can be monitored.

Application in Economic Development

Worldwide experience makes clear that economic development can be compatible with obtaining clean environments. Progress in all sectors, including agricultural modernization, industrialization, vehicularization, energy system expansion, and urbanization, can be achieved in a way that protects workers and the public. In addition, a healthy populace is an important prerequisite of economic growth: a healthy and educated workforce is necessary to achieve the rapid economic growth needed in India and elsewhere. Such sustained protection of human health, however, does not occur by itself, but through the dedicated and cooperative efforts of scientific and medical institutions, governments, the media, industry, and community groups.

The conference participants concluded that an absolute necessity for achieving sustainable development goals are clean environments and a healthy population and workforce.

Cancer of the Respiratory Tract

Lung cancer is the most common cancer in the developed regions of the world. The carcinogenic effect of tobacco smoke on the lung was demonstrated in the 1950s and has been widely recognized by public health and regulatory authorities since the mid-1960s. Some 80–90% of lung cancers are caused by tobacco and thus are potentially preventable. Underground miners exposed to radioactive radon gas and its decay products have been found to be at increased risk of lung cancer. Because of relative population sizes, however, the main concern for lung cancer risk from radon comes from residential rather than occupational exposure. Other established occupational lung carcinogens include asbestos, crystalline silica, arsenic, beryllium, cadmium, nickel, hexavalent chromium, and mixtures of polycyclic aromatic hydrocarbons (PAHs) such as coal tars, coal tar pitch, and soot. Chronic exposure to high levels of fibers and dusts may result in lung fibrosis (e.g., silicosis, asbestosis), which greatly increases the risk of lung cancer. Prevention of these occupational diseases is a challenge because the disease may take many years to appear; for example, silicosis has been reported to appear 15–20 years after workers have retired. Rigorous prevention strategies have been successful, however.

Two sources of indoor exposure to potential lung carcinogens include burning coal without proper ventilation and cooking at high temperatures using unrefined vegetable oils. High indoor levels of benzo[*a*]pyrene and other PAHs have been reported in such circumstances, and epidemiologic studies have linked exposures to elevated lung cancer risk (*5*). Conference participants emphasized the need for validating biomarkers to assess health affects of air pollution.

Public Health Policy

Exposure to air pollution, both indoor and outdoor, is associated with significant adverse impacts on human health, amounting to some 4–6% of the global burden of disease, with higher burdens in developing countries. Evidence of these health impacts motivates worldwide efforts to control air quality through a number of measures and controls. It is sometimes difficult to firmly link exposure to a specific chemical with an adverse health effect. In addition, health effects may take years or even decades to emerge.

The future scale of environmental and health problems from industrialization in developing countries will depend greatly on policy actions taken today. In Asia, for example, up to 70% of the power-generating capacity and 90% of the cars in use in 2013 will be added in the next 12 years. If current production practices continue, air pollution and toxic effluents from industrial production are likely to increase rapidly. However, if efficient and less-polluting technologies are used, many of the negative impacts of industrialization on health could be avoided. Decisions regarding the location sites of such polluting industries, the technologies used, and the type of precautions for occupational safety could have a tremendous impact on the future health of the people who live and work in developing nations. There is a need to reduce the workforce and to integrate toxicology and epidemiology knowledge.

The Industrial Toxicology Research Centre

The Industrial Toxicology Research Centre (ITRC), Lucknow, India, a constituent of the Council of Scientific and Industrial Research, was established in 1965 and is committed to providing health safeguards to industrial and agricultural workers through its rich knowledge base. The mission of the ITRC is to achieve the highest international standards in toxicologic research to ensure safety to human health and the environment and to help regulatory agencies in prescribing safe limits of chemicals.

The ITRC, in its early years of inception, focused activities on the problems of miners and other workers, who consistently inhale dusts and fibers. The ITRC undertook studies on toxicity of dyes, pesticides, and heavy metals. Subsequently, its activities expanded and covered toxicity studies of plastics, polymers, food colors, and solvents; the ITRC simultaneously worked on diagnostic, preventive, and interventional toxicology. Currently, the research at the ITRC is focused on understanding the mechanism of toxicity at the molecular level. It is also developing biomarkers for assessment of human exposure to chemicals and thus predicting the involved risk of exposure.

The Industrial Toxicology Research Centre, Lucknow, India.

The ITRC has reconsolidated its expertise with a view to give a new dimension to its motto, "Safety to environment and health and service to industry," and thus help to achieve its clearly defined objectives: *a*) identification of occupational health hazards due to exposure to chemicals in industries, mines, agricultural fields, and general environment by undertaking health and environmental surveys; *b*) studies for working out the mode of action of toxic chemicals, fibers and particles, and other pollutants; *c*) development of simple, rapid diagnostic tests for disorders caused by industrial and environmental chemicals; *d*) safety evaluation of chemicals used in industry, agriculture, and everyday life; *e*) suggest remedial and preventive measures to safeguard health and environment from pollutants, collection, storage, and dissemination of information on toxic chemicals; and *f*) human resource development to deal with industrial and environmental problems.

The strengths of the ITRC are the knowledge base and the analytical and experimental skills built through the last three decades in the areas of health risk assessment, preventive toxicology, predictive toxicology, environmental toxicology, inhalation toxicology, and analytical toxicology.

Another concern is that the industries that are heavily regulated in the developed world because of their harmful environmental and health impacts are migrating to the developing world. The asbestos industry is a good example. Production of asbestos has shifted from developed countries such as the United States to countries such as Brazil, India, Indonesia, Pakistan, and Korea. Although the consumption of asbestos is being phased out in developed countries, consumption in Brazil is increasing at about 7%/year. What is not used domestically is exported mainly to Angola, Argentina, India, Mexico, Nigeria, Thailand, and Uruguay.

Conclusions

Environmental and occupational respiratory diseases account for a significant portion of preventable illness and premature death in the world. These respiratory diseases result from common exposures to contaminants in households, workplaces, and outdoor environments. All countries share these problems, but the burden is greatest in developing countries such as India. The most important of the diseases known to have major environmental risk factors include pneumonia, chronic obstructive lung disease, TB, asthma, lung cancer, and various occupational lung diseases. Because there are no effective cures for most of these diseases, it is only through prevention that their burden on society can be lessened. These environmental diseases invariably affect the least advantaged and most vulnerable groups in society, including poor women and children, the malnourished, disenfranchised workers, and slum dwellers.

Major challenges are resource scarcity, workforce morbidity, poverty, illiteracy, and social attitudes toward work. More prevalent barriers in regulatory enforcement in developing countries are inadequate databases, stakeholder apathy, inadequate enforcement, and lack of political will. Conference participants suggested equalization and harmonization of research information between developed and developing countries.

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