

Editorial

The environment & health: an emerging area of research in India

It is no secret, either to the citizens of India or to the rest of the world, that many aspects of life in India are undergoing rapid and profound changes. The health consequences of earlier such changes have been predominantly for the better with, for example, a dramatic increase in life expectancy at birth for the average Indian from 31 yr in 1951 to 60 yr in 1991¹ as access to food, potable water, immunizations, and basic health care improved. However, some of the more recent changes have been less sanguine, such as the marked increase in obesity, type II diabetes, and associated cardiovascular morbidity that has begun to result from dietary shifts and the spread of sedentary lifestyles². Several other aspects of recent changes in India - in particular, rapid urbanization and population shifts to cities, industrialization, and a steep increase in the combustion of fossil fuels for energy and transportation needs - are also of deep concern and threaten to impede or even reverse improvements in life expectancy for broad segments of the population and impair function in both obvious and subtle ways.

How well do we understand the linkages between environment and health in India and is research on environmental health necessary for us to manage environmental hazards? One might argue that simply the adoption (and enforcement) of international guidelines (such as maintaining air or water quality standards) would be enough to address such problems.

However, environmental health research is critical to better define the risks posed by well-recognized hazards in the Indian context; to evaluate risks posed

by newly-recognized hazards that are specific to India; to identify vulnerable sub-populations; and to reveal mechanisms of disease causation. Knowledge gained in each of these areas is essential for guiding and prioritizing prevention efforts. Moreover, such research creates specific opportunities for India to improve its capacity for multidisciplinary research while developing a more integrated public health system. We herein outline some of the most important environmental health challenges in India and the potential role of research in addressing those challenges.

Well-recognized environmental hazards and India: An incomplete picture: In India, routinely collected environmental health indicators have focused on microbial contamination of water and access to sanitation. These continue to be the major environmental threats in both rural and urban settings. Indeed, evidence indicates that inadequate planning is beginning to reverse the benefits of urbanization in cities as many are grappling with the re-emergence of water and vector borne diseases³⁻⁵.

Population exposures with respect to newer hazards such as air pollutants (particles, sulfur oxides, carbon monoxide, oxides of nitrogen, ozone, and polycyclic aromatic hydrocarbons), toxic metals (lead, arsenic, mercury in air, water, and food), and organics (pesticides, solvents) remain understudied. Without more complete data, it is impossible to perform a risk assessment that can quantify, in any meaningful way, the contribution of environmental hazards to the burden of mortality and morbidity experienced now, or in the future.

That such an impact is occurring can no longer be doubted. For example, data from many international epidemiologic studies using time-series analyses (daily particle levels in relation to daily mortality) clearly demonstrate that exposure to PM_{10} (fine particles less than 10 microns in diameter) is associated with significant increases in risk for cardiopulmonary mortality⁶. Using estimates pooled from 90 cities in the U.S., a $10 \mu\text{g}/\text{m}^3$ increase in PM_{10} was predicted to result in an increase in daily total and cardiopulmonary mortality by 0.21 and 0.31 per cent, respectively⁷, and, with chronic exposure, an increase in lung cancer mortality of 8 per cent⁸. To put this into perspective, it is not uncommon to find 24 h averages of PM_{10} exceeding $150 \mu\text{g}/\text{m}^3$ even in residential neighbourhoods of Indian cities, a level at least 3 to 5 times of what is encountered in cities of developed countries⁹. Comparative risk assessments using available data, have estimated that the health care costs related to outdoor air pollution are comparable to those from microbial contamination of water. Together, these account for nearly two-thirds of the economic costs associated with environmental health damage across several metropolitan cities within India¹⁰⁻¹².

As another example, data from many studies across the world have clearly demonstrated that exposure to lead that is sufficient to raise blood lead levels in young children by $10 \mu\text{g}/\text{dl}$ is associated, on an average, with a decline in IQ of around 3 points¹³. These estimates, coupled with supportive animal studies, have persuaded many countries to set $10 \mu\text{g}/\text{dl}$ as a maximum level for children, with recent discussions on the need to lower this limit yet again¹⁴. In India, limited regional survey data from the late 1990s suggest that half of all children in India have blood lead levels exceeding $10 \mu\text{g}/\text{dl}$ ¹⁵ with early evidence that the effect on IQ is the same as in other countries¹⁶, alarming findings in a country for which a large segment of the rapidly increasing economy is based on the knowledge and service industries. Adults face risks as well, for example, using *in vivo* measurements of bone lead levels to characterize cumulative burdens, chronic environmental lead exposure has been recently found to be associated with increased risks for hypertension^{17,18}, accelerated

declines in cognition and kidney function^{19,20}, cataracts²¹ and trans-generational effects on the intelligence of offspring from the mobilization of lead from maternal bone during pregnancy²². Exposures to lead from vehicular emissions have likely come down in India since the introduction of unleaded gasoline in 1995, but exposure in cities continues to be of concern as a result of lead in water, food, soil and re-suspension of lead-laden dust²³.

Major concerns in the industrial environment, such as occupational lung diseases, musculoskeletal injuries, pesticide poisoning and noise induced hearing loss, have been examined in a number of research investigations led by the National Institute of Occupational Health (NIOH), the Industrial Toxicology Research Centre (ITRC) and the Central Labour Institute²⁴. In some cases, opportunities have unfortunately been missed to enact policies that would have largely prevented some of these hazards from spreading in India, with no better example than that of asbestos - a well known carcinogen and lung toxicant that is being aggressively marketed by foreign companies in India under the (spurious) rationale that the chrysotile form of asbestos being sold is less toxic²⁵. Some 10 million workers are estimated to be exposed to asbestos or other dusts at levels of concern²⁶.

Recently-recognized hazards that are more specific to India: There are also some environmental health risks specific for developing countries such as India that have remained understudied but that are now being appreciated as having major potential impacts on health. For example, contrary to earlier presumptions, rural India with little or no traffic/industrial outdoor sources, accounts for a large share of population particulate exposures due to indoor emissions from the combustion of biomass (*e.g.*, wood, animal dung, agricultural wastes) to meet domestic energy and cooking needs. Studies on health impacts elsewhere in the world²⁷, coupled with estimates and studies of exposures in India²⁸, suggest that such exposures are likely to be causing a large impact on respiratory morbidity in children and women with, for example, a 50 per cent increase in mortality from acute respiratory infections in infants²⁹.

Exposure to arsenic from the natural contamination of ground water derived from tube wells is a recently recognized catastrophe that affects up to 42 million people living in West Bengal^{30,31} and other areas of the Middle Ganga Plain such as Bihar³². Studies in India as well as Bangladesh, which is facing a similar crisis, have begun to confirm the risks posed by such contamination for symptomatic poisoning, neuropathy and neurovascular compromise, and cancers of the skin, lung, and other organs. Recent research has also begun to suggest adverse effects on reproduction as well as neurodevelopment in children³³.

Newer hazards in industrial environments such as exposure to blood borne pathogens, indoor air quality in buildings, ergonomic hazards associated with use of computers and occupational stress are seldom recognized due to a lack of awareness and technical manpower for routine industrial hygiene evaluations. India and several other developing countries also face fresh environmental threats from the relocation of hazardous industries as a consequence of the globalization of the world's economies. These production processes often entail risky occupational exposures and the discharge of large volumes of chemical wastes to soil and water. What risks do these pose to the communities surrounding these areas? Little such research has been conducted in India, and incentives to conduct such research no longer exist in the developed world.

Environmental health research in India: Its role and how to get there: Clearly, research that can clarify risk factors for exposure and the health impacts of many of the hazards discussed above is sorely needed in India. Research is needed on many levels, *e.g.*, studies of exposures and their magnitude; the relative importance of ingestion, inhalation, and dermal contact as routes of exposure for hazards that are environmentally pervasive; and the impact of selected hazards on accurate measures of health. Such research can provide the kind of information that can be directly used for formulating policies, prioritizing public health control efforts, and educating the medical community and public on the importance of environmental health and behaviours and policies that can mitigate the impact of hazards.

As the sophistication of India's biomedical research community grows, opportunities also exist for developing collaborative research endeavours that are more on the "cutting edge" of environmental health, such as epidemiologic cohort studies that utilize advanced biological markers of dose³⁴ and that have the large sample sizes required to address issues of vulnerable sub-populations. The latter may include, for example, studying interactions between exposures and pre-existing chronic diseases such as diabetes, hypertension²⁰ or coronary artery disease³⁵, and studying interactions between exposures and genetic polymorphisms that increase the risk of environmental disease³⁶. Progress can also be made in toxicogenomics, such as the use of DNA microarrays to characterize changes in gene expression associated with specific types of toxic responses³⁷. Efforts already underway at the ITRC and the NIOH supported by developments in India's biotechnology industry are likely to lay the foundations for such environmental genomics research at a national level.

Such progress in conducting environmental health research would be slow or impossible without the building of capacity and partnerships between India's medical and nascent public health establishments and collaborators around the world. Encouraging signs of the latter exist in the form of individual university-based collaborations and, for example, the establishment of the Joint Working Group on Indo-U.S. Collaboration in Environmental and Occupational Health by the Minister of the Indian Union of Health and Family Welfare and the U.S. Secretary of Health and Human Services in May 2002²⁶. But there is no occasion better than "World Environment Day" to remind us that much more work obviously remains.

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