

STATE-OF-THE-ART REVIEW

# Health Consequences of Environmental Exposures: Changing Global Patterns of Exposure and Disease



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## Abstract

Environmental pollution is a major cause of disease and death. Exposures in early life are especially dangerous. Patterns of exposure vary greatly across countries. In low-income and lower middle income countries (LMICs), infectious, maternal, neonatal, and nutritional diseases are still major contributors to disease burden. By contrast, in upper middle income and high-income countries noncommunicable diseases predominate. To examine patterns of environmental exposure and disease and to relate these patterns to levels of income and development, we obtained publically available data in 12 countries at different levels of development through a global network of World Health Organization Collaborating Centres in Children's Environmental Health. Pollution exposures in early life contribute to both patterns. Chemical and pesticide pollution are increasing, especially in LMICs. Hazardous wastes, including electronic waste, are accumulating. Pollution-related chronic diseases are becoming epidemic. Future Global Burden of Disease estimates must pay increased attention to the short- and long-term consequences of environmental pollution.

**KEY WORDS** pollution, non-communicable disease, children, low and middle income countries, public health

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## INTRODUCTION

Environmental pollution is a major cause of disease, death, and disability in countries around the world. The World Health Organization (WHO) calculates that pollution is responsible for approximately 7 million deaths per year, roughly equally attributable to

ambient and indoor air pollution<sup>1,2</sup>—a toll greater than the number of deaths caused by HIV/AIDS, malaria, and tuberculosis combined.<sup>3,4</sup> The vast majority (94%) of these pollution-related deaths occur in low-income and lower middle income countries.

Exposures to environmental pollution in early life are especially hazardous.<sup>5,6</sup> Susceptibility is greatest

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PDS and PJJ conceived the concept for the article. All authors contributed data from their country, with data gaps filled by JLS from on-line sources. PJJ wrote the first draft of the article, all authors gave comments and edits and PDS compiled the final version. All authors read and approved the final version.

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during “windows of vulnerability”—brief, precisely timed periods in embryonic, fetal, and early postnatal life when vital organs are sculpted through complex, highly choreographed, and tightly scheduled developmental processes. Exposures to harmful environmental influences during these critical periods can cause permanent anatomic, functional, and metabolic changes. It is now understood from research in pediatric toxicology,<sup>7</sup> nutritional epidemiology,<sup>8</sup> and psychosocial epidemiology<sup>9</sup> that even very low level exposures in early life to environmental pollutants, nutritional imbalance, or toxic stress can result in permanent alterations of organ function.<sup>10</sup> This dysfunction can manifest as acute or chronic disease at any point across the life span from early infancy to extreme old age.<sup>11</sup> Major acute diseases linked to environmental pollution in early life are pneumonia and diarrheal disease. Chronic, noncommunicable diseases (NCDs) linked to early environmental exposures include disorders of neurobehavioral development, adult and pediatric asthma, hypertension, obesity, diabetes, cardiovascular disease, and cancer. These associations are covered in more detail in the article by Sly *et al* published in this edition.<sup>12</sup>

Patterns of environmental pollution and of the diseases that it causes vary greatly from country to country. National income and level of development appear to be critical factors responsible for these sharp differences.<sup>13,14</sup> The goal of this report is to examine patterns of environmental pollution and pollution-related disease in different countries and to elucidate the links among those differing patterns, national income, and level of development. Specifically, the report examines the differences in environmental exposure and disease that exist in low-income countries (LICs), middle-income countries (MICs), and high-income countries (HICs). It will seek to elucidate links at each level of development between early exposures to environmental pollution and risk of disease across the life span. The report takes a broad health perspective, considering the acute health consequences in infancy and childhood of adverse exposures in early life as well as the long-term and delayed effects of early exposures that become manifest only in adult life. The report will focus especially on childhood conditions that WHO has designated as major contributors to burden of disease, including diarrheal diseases, lower respiratory infections, asthma, mental and behavioral diseases, complications of preterm birth, and transport injuries. The report argues that the magnitude of the

impact of environmental pollution on disease is insufficiently appreciated and seriously undercounted and that future analyses of the global burden of disease must place greater emphasis on hazardous environmental exposures, especially those encountered in early life. Finally, the report will examine the question of whether populations around the world are adequately protected by current legislation against hazardous exposures in the environment.

## METHODS

This report presents data on patterns of environmental exposure and disease in 12 countries at different levels of development<sup>15</sup>—Australia, Brazil, Canada, China, Ghana, Iran, Mexico, South Africa, South Korea, Switzerland, Thailand, and the United States (Table 1).<sup>16–19</sup> These data were collected from publically available official sources in each country, the Institute for Health Metrics and Evaluation, or WHO sources by physicians and scientists who are members of global network of Collaborating Centres in Children’s Environmental Health (CEH) that the WHO has constructed over the past decade in a wide range of countries at all levels of industrial and economic development. These Centres are now forming into a network to ensure effective collaboration and coordination of research efforts.<sup>20</sup> To date CEH Collaborating Centres have been designated in Australia, Brazil, Mexico, Japan, the Republic of Korea, Thailand, the United States, and Uruguay. The network is formally coordinated by the Collaborating Centre at the National Institute of Environmental Health Sciences.

**Table 1. Ranking of 12 Countries on Human Development Index, 2014**

High Income	Australia	2
	Switzerland	3
	United States	5
	Canada	8
	Republic of Korea	15
Upper Middle Income	Mexico	71
	Iran	75
	Brazil	79
	Thailand	89
Lower Middle Income	China	91
	South Africa	118
Low-Income	Ghana	138

Source: United Nations Development Programme, 2014.<sup>15</sup>

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