

Environmental Threats to Children's Health in Southeast Asia and the Western Pacific

William A. Suk,¹ Kuhnying Mathuros Ruchirawat,² Kalpana Balakrishnan,³ Martha Berger,⁴ David Carpenter,⁵ Terri Damstra,⁶ Jenny Pronczuk de Garbino,⁷ David Koh,⁸ Philip J. Landrigan,⁹ Irma Makalinao,¹⁰ Peter D. Sly,¹¹ Y. Xu,¹² and B.S. Zheng¹³

¹Center for Risk and Integrated Sciences, National Institute of Environmental Health Sciences, Research Triangle Park, North Carolina, USA;

²Chulabhorn Research Institute, Bangkok, Thailand; ³Sri Ramachandra Medical College and Research Institute, Porur, Chennai, India;

⁴Office of Children's Health Protection, U.S. Environmental Protection Agency, Washington, DC, USA; ⁵School of Public Health, University at Albany, Rensselaer, New York, USA; ⁶World Health Organization, International Programme on Chemical Safety, Research Triangle Park, North Carolina, USA; ⁷World Health Organization, International Programme on Chemical Safety, Geneva, Switzerland; ⁸National University of Singapore, Department of Community, Occupational and Family Medicine, Singapore; ⁹Center for Children's Health and the Environment, Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York, New York, USA;

¹⁰Department of Pharmacology and Toxicology, University of the Philippines College of Medicine, Manila, Philippines; ¹¹Princess Margaret Hospital for Children, Child Health Research, Subiaco, Washington, USA; ¹²Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, People's Republic of China; ¹³Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, People's Republic of China

The Southeast Asia and Western Pacific regions contain half of the world's children and are among the most rapidly industrializing regions of the globe. Environmental threats to children's health are widespread and are multiplying as nations in the area undergo industrial development and pass through the epidemiologic transition. These environmental hazards range from traditional threats such as bacterial contamination of drinking water and wood smoke in poorly ventilated dwellings to more recently introduced chemical threats such as asbestos construction materials; arsenic in groundwater; methyl isocyanate in Bhopal, India; untreated manufacturing wastes released to landfills; chlorinated hydrocarbon and organophosphorous pesticides; and atmospheric lead emissions from the combustion of leaded gasoline. To address these problems, pediatricians, environmental health scientists, and public health workers throughout Southeast Asia and the Western Pacific have begun to build local and national research and prevention programs in children's environmental health. Successes have been achieved as a result of these efforts: A cost-effective system for producing safe drinking water at the village level has been devised in India; many nations have launched aggressive antismoking campaigns; and Thailand, the Philippines, India, and Pakistan have all begun to reduce their use of lead in gasoline, with resultant declines in children's blood lead levels. The International Conference on Environmental Threats to the Health of Children, held in Bangkok, Thailand, in March 2002, brought together more than 300 representatives from 35 countries and organizations to increase awareness on environmental health hazards affecting children in these regions and throughout the world. The conference, a direct result of the Environmental Threats to the Health of Children meeting held in Manila in April 2000, provided participants with the latest scientific data on children's vulnerability to environmental hazards and models for future policy and public health discussions on ways to improve children's health. The Bangkok Statement, a pledge resulting from the conference proceedings, is an important first step in creating a global alliance committed to developing active and innovative national and international networks to promote and protect children's environmental health. **Key words:** Bangkok, children's environmental health, exposure, lead, mercury, risk, Southeast Asia, Western Pacific. *Environ Health Perspect* 111:1340–1347 (2003). doi:10.1289/ehp.6059 available via <http://dx.doi.org/> [Online 13 May 2003]

"We recognize that a growing number of diseases in children have been linked to environmental exposures . . . that environmental exposures are increasing in many countries . . . that new emerging risks are being identified, and that more and more children are being exposed to unsafe environments." This quotation from the Bangkok Statement (the Bangkok Statement; WHO 2002b) represents the consensus of participants at the International Conference on Environmental Threats to the Health of Children: Hazards and Vulnerability, held in Bangkok, Thailand, 3–7 March 2002. The goals of this conference were to identify specific environmental threats to the health of children in the Southeast Asian and Western Pacific regions, to raise the awareness on the

special vulnerability of children, and to discuss examples of effective solutions and prevention/intervention strategies. The Bangkok Statement can be considered a model for national and international calls to action for all sectors to work jointly to protect children's health against environmental threats.

Environmental threats to the health of children in Southeast Asia and the Western Pacific are myriad, and include the classic infectious disease hazards: pneumonia, dysentery, measles, AIDS, and tuberculosis (Wegman 1999). Moreover, as industrial development proceeds and nations pass through the epidemiologic transition (Orman 1971), children are confronted by a rapidly multiplying array of new threats to health posed by exposures to toxic

chemicals. In recognition of these new threats, the evaluation and management of risk to human health from exposures to chemicals have grown progressively since the 1970s.

Solutions to environmental health problems have emerged from Southeast Asia and the Western Pacific. Pediatricians, environmental health scientists, educators, public health workers, and representatives of governmental and nongovernmental organizations in several of the countries have begun to implement culturally appropriate research and prevention programs in children's environmental health. Their commitment to ensuring the success of these programs and prevention strategies through action at the local, regional, and national levels has been reinforced through the words of the Bangkok Statement.

In this article we review the current status of environmental threats to children's health in the Southeast Asia and Western Pacific regions and report on recent solutions applied in these regions in an effort to reduce these threats. These status reports have been drawn primarily from discussions and proceedings presented at the International Conference on Environmental Threats to the Health of Children, sponsored

Address correspondence to W.A. Suk, NIEHS, 79 T.W. Alexander Dr., 4401 Bldg, Mail Drop EC-27, Research Triangle Park, NC 27709 USA. Telephone: (919) 541-0797. Fax: (919) 541-4937. E-mail: suk@niehs.nih.gov

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jointly by the World Health Organization (WHO), the Chulabhorn Research Institute, the U.S. National Institute of Environmental Health Sciences (NIEHS), the U.S. Environmental Protection Agency (U.S. EPA), the Swedish International Development Fund, and the German Federal Prevention Agency. The review concludes with a vision for the future promotion and protection of children's environmental health. A complete transcription of the Bangkok Statement appears in Appendix 1, and a list of organizations and websites in Appendix 2.

Geography and Demographics

Approximately one-quarter of the global burden of disease (GBD) can be attributed to environmental risk factors. More than 40% of this burden falls on children younger than 5 years (WHO 2002b). The Southeast Asian region includes 10 countries with a total population of approximately 1.5 billion, of whom 180 million are 0–4 years old and 614 million are younger than 18 years. The Western Pacific region includes 34 countries with a total population of approximately 1.7 billion, with 132 million children 0–4 years of age, and 507 million persons younger than 18 years. Together, these two regions contain 53.1% of the world's population and 52% of the world's children (Table 1). Infant mortality rates and calculated life expectancy at birth vary widely in nations across these regions, reflecting different levels of economic and public health development (Table 2).

Poverty is a major predictor of ill health in these regions and throughout the world, making children living in poor conditions particularly vulnerable to diseases of all kinds. Three-quarters of the world's poor live in Asia, with one of every three people in the region lacking a safe water supply and one in every two lacking adequate sanitation (WHO 2002b). Poverty is often associated with malnutrition, unhealthy environments, poor sanitation, and lack of access to health care. Environmental hazards, in conjunction with social stress and malnutrition, pose almost insurmountable barriers to a child's normal development (Suk 2002).

Contaminated air, food, and drinking water are particularly significant environmental threats facing children in poor countries. Children living in poor conditions are known to scavenge for food, which exposes them not only to contaminated food and water but also to such diseases as malaria, dengue, and others spread by rodents living in garbage dumps (Carpenter et al. 2000). Half a billion children worldwide are debilitated or killed each year by infectious diseases such as malaria, schistosomiasis, and cholera. Poisonings and accidents also continue to be major contributors to child morbidity and mortality.

Unsafe water, sanitation and hygiene, and indoor smoke from solid fuels are two of the top 10 risk factors contributing to the GBD in the poorest regions of the globe (Ezzati et al. 2002). An estimated 1.7 million children die each year because of unsafe water, and poor sanitation and hygiene; nine out of 10 of these deaths occur in children, primarily through infectious diarrhea. Of this 1.7 million, one-third of the deaths occur in countries in Southeast Asia that have high child-mortality rates. Of the 2.7% of the GBD attributed to indoor smoke, 37% of the total burden occurs in countries in Southeast Asia that have high child-mortality rates, and 16% occurs in Western Pacific countries that have low child-mortality rates (WHO 2002c).

Industrialization and Urbanization of Southeast Asia and the Western Pacific

Industrialization and urbanization brought economic growth and health benefits to the Southeast Asia and Western Pacific regions. This is dramatically illustrated by the major increases in wealth that have occurred over the

past half-century in nations such as Japan, South Korea, Thailand, and Singapore. A major consequence of this economic growth, however, is that over the past 20–50 years, many nations have passed through the “epidemiologic transition” (Orman 1971). In these more industrially developed nations, the classic infectious disease threats to children's health have largely been controlled through the provision of safe drinking water and adequate food, waste disposal, and immunizations. Infant mortality has declined sharply. The predominant diseases of children have now become the suite of chronic illnesses termed the “new pediatric morbidity”—asthma, learning disabilities, congenital malformations, and cancer—that are also the leading causes of morbidity and mortality for children in Western Europe and North America (Landrigan et al. 1998).

Globally, children's health is now frequently endangered by exposure to natural or man-made toxic chemicals in the air, water, soil, and food chain. Children are especially at risk of exposure to the approximately 15,000 high-production-volume chemicals that are produced in largest quantities worldwide and

Table 1. Population of Southeast Asia and Western Pacific.

	Total population (thousands)	Age (years; thousands)	
		0–4	0–17
Southeast Asia			
Bangladesh	137,952	19,330	63,336
Bhutan	2,063	322	1,021
India	1,016,038	120,878	409,120
Indonesia	211,559	21,747	78,369
Maldives	291	47	148
Myanmar	47,544	5,392	18,654
Nepal	23,518	3,549	11,077
North Korea	22,268	1,932	7,002
Sri Lanka	18,595	1,514	5,933
Thailand	60,925	5,247	19,454
Total	1,540,753	179,958	614,114
Western Pacific			
Australia	19,153	1,265	4,744
Brunei Darussalam	334	38	122
Cambodia	13,147	2,046	5,828
China (including Taiwan and Hong Kong)	1,275,215	96,586	378,803
Fiji	814	97	324
Japan	127,034	6,055	22,975
Lao People's Democratic Republic	5,279	836	2,601
Malaysia	23,001	2,737	9,152
Micronesia ^a	499	64	212
Mongolia	2,500	268	1,052
New Zealand	3,784	277	1,032
Papua New Guinea	5,334	830	2,257
Philippines	75,711	9,834	33,395
Polynesia ^b	611	75	258
Singapore	4,016	274	1,027
Solomon Islands	437	71	220
South Korea	46,835	3,112	12,039
Vanuatu	197	30	97
Vietnam	78,137	7,743	31,139
Total	1,682,038	132,238	507,277
World	6,070,581	617,204	2,168,610
Population in Southeast Asia and Western Pacific (%)	53.1	50.6	51.7

Data from UN (2003).

^aMicronesia consists of Guam, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Northern Mariana Islands, and Palau. All but Guam have populations of less than 100,000. ^bPolynesia consists of American Samoa, Cook Islands, French Polynesia, Niue, Pitcairn, Samoa, Tokelau, Tonga, Tuvalu, and the Wallis and Futuna Islands. American Samoa, Cook Islands, Niue, Pitcairn, Tokelau, Tuvalu, and the Wallis and Futuna Islands have populations of less than 100,000.

that have the potential to be most widely disseminated in the environment, nearly all of them developed in the past 50 years. These chemicals include such neurotoxic substances as lead, solvents, mercury, pesticides, and polychlorinated biphenyls (PCBs) (Landrigan et al. 1998). Fewer than half of these high-production-volume chemicals have been tested for their potential toxicity, and fewer still for their possible developmental toxicity to fetuses, infants, and children (National Academy of Sciences 1984; U.S. EPA 1998). Increasingly, it has come to be understood that children's exposures to these chemicals have contributed to changing patterns of pediatric disease and especially to the increasing incidence of certain chronic diseases in children.

Perhaps the most dramatic example of the threat posed by chemical hazards in the environment to the nations of Southeast Asia was the 1984 disaster at Bhopal, India, in which a pesticide factory exploded and spewed out methyl isocyanate (Varma and Guest 1993). Thousands died and thousands more were seriously injured. Other examples of chemical hazards in this region include air pollution in Bangkok, arsenic toxicity in Bangladesh (Smith et al. 2000), pesticide poisoning, and the importation of vast quantities of asbestos

(Nicholson and Landrigan 1996). A new threat is posed by the export of postconsumer electronic waste from developed nations to Asia, where labor is cheap and occupational and environmental protections are often inadequate. Uncontrolled recycling and disposal processes include open burning of plastics, acid baths, and dumping, and they result in the release of toxic materials into the land, air, and water. Asia's poorest populations are exposed to the lead, mercury, hexavalent chromium, beryllium, cadmium, and brominated flame retardants emitted by these operations (Puckett et al. 2003).

With the continuing transfer of hazardous chemicals and toxic wastes from the developed to the developing world, children in developing nations are placed at double jeopardy in which they are at risk simultaneously for infectious diseases and chemical hazards. Sadly, Bhopal appears not to have been an exception, but rather a harbinger of things yet to come.

Children's Unique Vulnerability

Children are particularly vulnerable to environmental toxins. Several factors have the effect of increasing children's potential risk (National Academy of Sciences 1993):

Children have disproportionately heavy exposures to environmental toxicants. Pound for pound of body weight, children drink more water, eat more food, and breathe more air than do adults. The health implication of these findings is that children will have substantially heavier exposures than adults to any toxicants that are present in water, food, or air.

Children's metabolic pathways, especially in the first months after birth, are immature. Children's ability to metabolize, detoxify, and excrete many toxicants is different from that of adults. In most instances, they are less able to deal with toxic chemicals and thus are more vulnerable to them.

Children undergo rapid growth and development, and their developmental processes are easily disrupted. Many organ systems in infants and children undergo very rapid change prenatally as well as in the first months and years after birth. These developing systems are very delicate and are not well able to repair damage that may be caused by environmental toxicants.

Because children have more future years of life than most adults, they have more time to develop chronic diseases triggered by early exposures. Many diseases are triggered by early exposures. Those that are caused by toxicants in the environment are now thought to arise through stages that require years or even decades to evolve from earliest initiation to actual manifestation of disease. Carcinogenic and toxic exposures sustained early in life, including prenatal exposures, appear more likely to lead to disease than are similar exposures encountered later.

Specific Environmental Health Threats to Children in the Region

Environmental health threats in Southeast Asia and the Western Pacific are numerous—ranging from the more traditional health hazards, such as poor sanitation and unsafe waste disposal, to those caused by the introduction of toxic chemicals such as lead and pesticides. Several speakers at the Bangkok conference discussed examples of environmental health hazards currently facing children in these regions.

Lead. In China, the environmental lead emissions of a lead smelter and the effects of these emissions on health have been studied for 15 years. The lead content in rice, vegetables, and drinking water and the blood lead levels of 104 schoolchildren 7–14 years old in the polluted area and of 86 children in the control area were determined. In the polluted area, 22 schoolchildren's blood lead levels exceeded 30 µg/d; for eight schoolchildren blood lead reached as high as 45–75 µg/dL. The children's weights and heights, rates of sick leave per semester, and incident rates of upper respiratory infection were also surveyed. Significantly lower levels of weights

Table 2. Southeast Asia and Western Pacific infant and child mortality rates.

	No. of deaths per 1,000 live births ^a		Life expectancy at birth (years)
	Infants	Children < 5 years old	
Southeast Asia			
Bangladesh	64	87	61.4
Bhutan	53.6	80	63.2
India	64.5	84	63.9
Indonesia	41.6	52	66.8
Maldives	38.3	49	67.4
Myanmar	83.5	128	57.3
Nepal	70.9	98	59.9
North Korea	45	58	63.1
Sri Lanka	20.1	23	72.6
Thailand	19.8	25	69.3
Western Pacific			
Australia	5.5	7	79.2
Brunei Darussalam	6.1	7	76.3
Cambodia	73.2	107	57.4
China (including Taiwan and Hong Kong)	36.6	43	71
Fiji	17.8	22	69.8
Japan	3.2	4	81.6
Lao People's Democratic Republic	88	141	54.5
Malaysia	10.1	13	73.1
Micronesia	20.6	26	72.0
Mongolia	58.2	85	63.9
New Zealand	5.8	7	78.3
Papua New Guinea	62.1	85	57.6
Philippines	29	35	70
Polynesia	21.1	26	71.0
Singapore	2.9	4	78.1
Solomon Islands	20.7	30	69.2
South Korea	5.0	7	75.5
Vanuatu	28.5	35	68.8
Viet Nam	33.6	45	69.2
World	55.6	81	65.4

Data from UN (2003).

^aThe probability of dying between birth and exact age (birthday) 1 for infants and age 5 for children. Child mortality is the probability of dying between birth and exact age 5. Data are for 2000.

and heights, significantly higher rate (2.2%) of sick leave, and a higher relative risk of catching a cold were observed in children in the polluted area compared with those in the control area. These findings indicate that the children's development had been impaired and their susceptibility to pathogens increased in the lead-polluted area (Ling 2002).

Pesticides. In most developing countries, about 80% of the rural population is engaged in agricultural activities in which children participate. In these countries, the organochlorine insecticides such as DDT (dichlorodiphenyl-trichloroethane), which are banned in developed countries, are still used extensively. These compounds are persistent in the environment. Studies in many parts of the world, including India, have shown significantly high incidence of abortions, childhood cancers, undescended testicles, and congenital malformations in children of the parents occupationally exposed to pesticides. Controlled use and total avoidance of exposure to pesticides during pregnancy may help minimize exposure-related health problems (Saiyed 2002).

Indoor air pollution. More than half of the world's population, mainly rural inhabitants from developing nations, rely on coal and solid biomass fuels such as wood, dung, and crop residues for cooking. These solid fuels are burned incompletely within dwellings in simple stoves with little provision for ventilation. The consequence is accumulation indoors of high levels of indoor air pollutants such as coarse and fine particulate matter, carbon monoxide, oxides of nitrogen, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds such as benzene, toluene, and formaldehyde. Women and children are subjected to the longest and most intense exposures because of their proximity to the source and greater length of stay indoors. Epidemiologic evidence suggests a link between indoor air pollution in such homes and low birth weight, increased infant and perinatal mortality, and acute respiratory tract infections in children. Other diseases that have been linked with indoor air pollution from the combustion of domestic fuels are tuberculosis, cataracts, and cancers (only with coal) of the nasopharynx and lungs (Saiyed 2002).

Global climate change and children's health. The distinctive aspect of global environmental change is its vast scale. For the first time, humankind is exerting sufficient aggregate pressure on Earth's biophysical systems to induce changes in environmental processes and conditions at a global level. Several global environmental changes are now confirmed—particularly stratospheric ozone depletion and global warming. These large-scale environmental changes do not entail qualitatively novel health hazards, but they will greatly amplify and disseminate the health risks posed by

many existing environmental hazards, such as extreme weather events, thermal stress, food and water shortages, and increased ultraviolet radiation exposure at middle to high latitudes. Changes in land use, climatic conditions, and surface water all will influence the geographic range and density of infectious disease vectors such as mosquitoes and ticks. Additionally, many of these environmental changes will affect crop production, fruit and vegetable production, and animal husbandry.

Some of the most likely impacts of climate change upon children's health include *a*) increased risk of diarrheal disease, due to flooding and a lack of clean fresh water; *b*) induction/exacerbation of allergic disorders; *c*) malnutrition and stunting in food-insecure populations, as a consequence of climatic impacts on regional food production; *d*) vector-borne infectious diseases such as malaria that particularly endanger children; *e*) heightened child susceptibility to thermal extremes—infant death rates go up during these times; and *f*) the usual health hazards of population displacement, with special additional consequences for children because of the disruption of family and community social networks. There has been very little empirical research into the specific impacts of global environmental change on the health of children (McMichael 2002).

Persistent organic pollutants. The recent results of ecotoxicologic research indicate that persistent organic pollutants (POPs) in the environment, especially those that are known as endocrine-disrupting chemicals (EDCs), such as organochlorines and phthalates, can mimic hormones to disrupt the endocrine system of wildlife. The endocrine disruptions of some POPs were observed in experiments exposing fertilized fish eggs to POPs at low doses until the offspring were fully grown. Results of these exposures demonstrated profound long-term health effects, including reproductive disorders, developmental deformities, and sex feminization. The endocrine disruption of POPs in wildlife is an early warning that the environment threatens human health. POPs can be transferred over long distance and become ubiquitous, exposing humans to thousands of chemicals every day by different routes, particularly through food consumption. Residual pesticides, antibiotics, fertilizers, plasticizers, and other POPs found in foods required by children for growth and development, as well as contamination introduced during food production, transportation, processing, and storage, are a major concern for children's health (Xu 2002).

There is increasing concern that low-level exposure to EDCs may have adverse health impacts, particularly during fetal, neonatal, and childhood development. Both the nature and severity of health outcomes may depend

on the developmental time window during which chemical exposure occurs. Adverse health effects of concern in children include altered reproductive development and function, impaired neurobehavioral development, and immune suppression (Damstra 2002).

Mercury. Approximately 10 million people are estimated to be involved in small-scale gold mining operations throughout the world, including activities in countries such as the Philippines, Indonesia, and China. The mining activities have contaminated irrigation and water systems, resulting in fish kill and affecting livestock and agricultural production. Methylmercury exposure of workers and their families occurs with the intake of contaminated marine and aquatic organisms secondary to pollution of biota from mine tailings and indiscriminate disposal of mercury. Because of the highly toxic nature of mercury, workers exposed to the compound exhibited chest pain, dyspnea, cough, hemoptysis, and evidence of interstitial pneumonitis. Cases of fetal-type Minamata disease caused by mothers' exposures to methylmercury during pregnancy were also reported. Symptoms of this disease include cerebellar ataxia, central hearing impairments, and central disequilibrium (Cortes-Maramba et al. 2002).

Solutions

Given the real danger these hazards pose to children and the increasing level of awareness among governments and communities in these regions regarding the need to implement preventive measures, action is being taken to reduce children's exposures to environmental health threats. Following are examples of collaborative efforts implemented by and among local, regional, national, and multilateral entities to protect children's health and raise awareness of the availability of and need for cleaner, more efficient technologies that are safe for children and the environment.

Removal of lead from gasoline. In Pakistan, increased wealth and population growth has accelerated growth of the vehicle population and the amount of travel. The number of these motor vehicles operating on leaded gasoline has also increased. The high content of lead in gasoline is a serious issue because the lead is released into the environment. In developing countries such as Pakistan, children with dietary deficiencies are even more susceptible to lead poisoning caused by this increase in traffic and the use of leaded gasoline. The lead content of gasoline in Pakistan has been measured at 0.35 g/L, a very high level compared with maximum lead contents of 0.00–0.15 g/L in countries such as the United States. Further, reported lead levels in the air of Pakistani cities such as Karachi, Lahore, and Peshawar indicate an alarming increase in and high levels of lead in the ambient air at the reported sites and

time of monitoring. Because of these reported levels, blood lead levels were studied in more than 900 healthy children in some cities throughout Pakistan. The overall mean blood lead levels (micrograms per deciliter) in the three cities were found to be 22.8 ± 3.30 , 19.00 ± 6.48 , and 2.30 ± 0.19 (rural site). The existence of such an alarming environmental health threat to children in Pakistan has led to the government's creation of a National Environment Action Plan, intended to reduce poverty and bolster economic growth. As part of this umbrella program, fuel efficiency projects aim to reduce at-source emissions of greenhouse gases and other pollutants by improving fuel efficiency for transport vehicles in Pakistan. Lead phaseout programs intended to provide clean fuel in the country are also part of this broader action plan (Khwaja 2002).

The India clean-water project. Although access to drinking water in India has increased over the past decade, the tremendous adverse impact of unsafe drinking water on human health continues. Twenty-one percent of communicable diseases in India are estimated to be water related. The highest mortality rate from diarrhea occurs in children younger than 5 years, and there is an urgent need for focused interventions to prevent diarrheal disease in this age group. Despite investments in water and sanitation infrastructure, many low-income communities in India and other developing countries continue to lack access to safe drinking water, proper sanitation and sewage systems, garbage collection networks, and information and education on healthy hygiene and sanitation practices. Currently available strategies and technologies to make water safe to drink are unaffordable and inaccessible to most low-income households, particularly those without a regular piped water supply.

The Safe Water System (SWS), an effective and inexpensive intervention to provide safe drinking water, was developed by the U.S. Centers for Disease Control and Prevention (CDC) and the Pan American Health Organization (CDC 2002). The SWS intervention consists of *a*) point-of-use treatment of contaminated water with locally produced sodium hypochlorite solution, packaged in locally available bottles with a 5–10 mL cap that serves as a dosing device; *b*) safe water storage in plastic containers with a covered narrow mouth and a spigot to prevent recontamination; and *c*) behavior change techniques, including social marketing, community mobilization, and innovative information, education, and communication.

The WHO has promoted the SWS in India and Bangladesh in collaboration with the CDC and is currently partnering with India's Population Services International (PSI), India and Sulabh International Institute of Health and Hygiene (SIHH; New Delhi, India) to

introduce SWS widely in India. A feasibility pilot funded by the WHO, to assess SWS's potential to reduce diarrheal diseases in low-income populations, with a special emphasis on children younger than 5 years, is currently underway in eight slum communities in West Delhi (October 2001 and September 2003).

PSI is also designing and implementing innovative behavioral change communications strategies based on qualitative and quantitative consumer research. PSI is creating demand for and providing access to sodium hypochlorite solution and safe water storage containers in the pilot communities. This demand creation will be linked to a behavioral change communications campaign designed to raise awareness of clean practices around water use and storage, hygiene, sanitation, and garbage disposal. The primary audience for key messages will be families with children younger than 5 years. The campaign includes the use of mass media and local, culturally appropriate media. SIHH is working closely with PSI to train resident community volunteers (themselves slum residents) to execute a range of community activities, including household visits and community events. Performance-based incentives will be offered to volunteers to enhance sustainability (Jafa 2002).

Mercury pollution reduction project. The United Nations Industrial Development Organization (UNIDO) is working to reduce mercury pollution through the implementation of a global action project that focuses on four major areas: *a*) awareness raising and training; *b*) reduction of mercury pollution; *c*) demonstration of cleaner technology; and *d*) development of policies and legislation. The awareness raising and training components of the project would provide on-the-job training of cleaner technologies, and awareness campaigns would be conducted through workshops and the media. Reduction of mercury pollution would use an evidence-based approach based on geochemical and human monitoring to identify hot spots. Once hot spots are discovered, measures to remediate these areas will be formulated. To demonstrate advantages of cleaner technology, manufacturers will be made aware of the cost-effectiveness of alternative techniques, a databank of technologic requirements will be established, and microfinancing schemes will be developed and tested. To improve policies and legislation, governments will receive assistance to review current policies and to develop enforceable standards (Garbe 2002).

International networking. The International Research and Information Network on Children's Health, Environment and Safety (INCHES) is a global network of people and organizations interested in promoting the protection of children from environmental and safety hazards. INCHES organizers and supporters believe that promoting children's

health requires protecting children from harmful environmental exposures, including harmful physical, chemical, and biologic microorganisms and pollutants in water, air, soil, and food. The president of INCHES, Dr. Peter van den Hazel, shared lessons in starting a network with participants of a round table on Building Partnerships at the Bangkok conference. He stressed several key aspects, including the need to consider various fundraising strategies, human capital needs, engaging all potential stakeholder groups, and thinking about how the new network will grow and operate (national vs. local; membership vs. open network). INCHES disseminates information and will initiate research on the relationship between environmental factors and child health. News and updates relevant to children's environmental health are available at <http://www.inchesnetwork.org/index.html> as the network develops (van den Hazel 2002; WHO 2002b).

Antismoking campaigns. Environmental tobacco smoke (ETS) is a major contributor to indoor air pollution. There is growing concern worldwide about the effects that ETS has on children, because their lungs are smaller and their immune systems are less developed than those of adults. Data indicate that children whose fathers smoke are at a 30% higher risk of suffering from respiratory diseases and middle ear infections. That risk increases if the mother is also a smoker. With the support of the Rockefeller Foundation, the National Poison Control Center of Malaysia has developed the Clearinghouse for Tobacco Control (<http://www.ctob.org>). The goal of the clearinghouse is to provide up-to-date information on the Internet, allowing for interactive communication between users and the website. The efforts of this clearinghouse will initially target the general populace of Southeast Asia, helping to increase their awareness of the dangers of smoking and encourage them to proactively protect children from the ill effects of ETS. Over time, it is hoped that the clearinghouse's efforts will effectively spur policies intended to curb the health threats of ETS (Awang and Makalinao 2002). After the conclusion of the Bangkok conference the Clearinghouse for Tobacco Control, together with the Ministry of Health, Malaysia, and the Southeast Asia Tobacco Control Alliance, coordinated a regional workshop that was held in Panang, Malaysia, on 23–26 September 2002, titled "Communicating the Evidence for Tobacco Control." Representatives from the 10 Association of Southeast Asian Nations (ASEAN) countries, including researchers and advocates, met to discuss four key areas of concern to curb the tobacco epidemic: smoke-free areas, advertising and promotion, taxation, and packaging and labeling (Makalinao IR. Personal communication).

Major Needs in the Global Burden of Environmental Diseases in Children

Research and prevention programs in environmental health, such as those outlined above, are positive steps intended to address the numerous environmental hazards facing children in Southeast Asia and the Western Pacific. They also reflect the increased level of awareness within these regions regarding the need for immediate and positive change in order to realize environmental health benefits in the longer term. However, much remains to be done. Besides the efforts already taking place at the local, regional, and national levels within these countries, several needs at the global level will require a coordinated response and allow us to understand better the needs of specific regions within the context of an international scientific agenda (Carpenter et al. 2000; Smith et al. 1999):

- There is a need for more and better-coordinated local and global data collection on environmental exposures in children related to health impacts and to disease etiologies.
- A global, strategic, epidemiologic effort is necessary to fill gaps in our understanding of the relationship between environmental exposure and ill health in children (e.g., an international children's cohort).
- The entire environmental pathway from driving forces to health impact needs to be considered when designing interventions to improve the environment and health of children.
- There is a need to develop a better understanding of the mechanism(s) and interactions among infectious diseases, environmental exposures, and genetics and predisposition needs to be developed in order to develop better prevention methods.
- Epidemiologic research is needed to explore associations between environmental exposures and disease.
- Basic research is needed to elucidate mechanisms of disease and to explore gene-environment interactions.
- Evidence-based approaches to prevention need to be developed and field tested.

The creation of an international network of pediatric environmental health and disease prevention research centers is one solution that may help close the gaps that currently exist in our understanding of the relationship between environmental exposures and children's health. A model for this international network already exists in the United States: The Centers for Children's Environmental Health and Disease Prevention Research were established in 1998 by the NIEHS, the U.S. EPA, and the CDC. Twelve centers located throughout the United States conduct multidisciplinary research in conjunction

with community-based prevention research projects to support studies on the causes and mechanisms of children's disorders having an environmental etiology and to identify relevant environmental exposures. Ideally, a coordinated international centers program would focus on exposure assessments, health effects research, development and validation of risk management, and health prevention strategies. Such a network would require multidisciplinary interactions among basic, clinical, and behavioral scientists, with a central communications framework intended to foster continued dialogue among and between center programs and researchers. The Bangkok Statement promotes the creation of such a "Centres of Excellence" program, seeking financial and institutional support for the research, information collection, education, and training activities it would likely support.

The Future of Children's Environmental Health

The International Conference on Environmental Threats to the Health of Children in Bangkok was one in a series of international meetings intended to build on more than a decade of effort by the WHO, the United Nations Environment Programme, and numerous other stakeholders from around the globe to recognize the linkages between children's health and the environment and define a solid commitment to action to promote and protect children's environmental health. Formal calls for specific action such as the Declaration of the Environment Leaders of the Eight (G8) on Children's Environmental Health in 1997 (WHO 2001), the renewed commitment and pledge made by the United Nations General Assembly Special Session on Children earlier this year (UN 2002), and the Bangkok Statement have effectively summarized growing concerns about the future of children's environmental health and help define a clear path toward the creation of a global alliance committed to the principles of protection and prevention, health care and research, empowerment and education, and advocacy. To move forward, this global alliance must build from the successful past work of decision makers, public health officers, researchers, and community members and be guided by a vision intended to address several basic truths:

- The health of children is threatened by environmental toxins.
- All children in every country and every community have the right to be protected against environmental threats to their health.
- Poor children are most at risk for environmental quality problems.
- There is a critical lack of knowledge about environmental threats to children's health.

- There is a critical shortage of researchers and clinicians trained in children's environmental health.

Fortunately, the foundation for such a global alliance exists and is currently in the beginning stages of development. On 1 September 2002, the WHO initiated a global alliance created to tackle the worldwide environmental crisis affecting children's health at the World Summit on Sustainable Development, in Johannesburg, South Africa (WHO 2002a). This new movement, called the Healthy Environments for Children Alliance (HECA), will address the worldwide environmental crisis affecting children's health. "Healthy Environments for Children" was also chosen by the WHO as the theme for World Health Day, which took place on 7 April 2003 (WHO 2003). HECA will focus on six main areas of environmental risks to children: household water quality and vulnerability, hygiene and sanitation, indoor and outdoor air pollution, disease vectors, chemicals (pesticides and lead), and accidents and injuries. Its work will involve actors at all levels in an effort to consolidate and disseminate scientific knowledge on children's health, environmental hazards, and their linkages; spur further investment in research on environmental risk factors and the evaluation of cost-effective interventions; raise awareness among health professionals about the linkages between children's health and environmental risk factors; encourage multisector approaches toward preventive actions; and empower governments and local actors to make informed policy actions aimed at maintaining healthy environments so that their children can develop in a healthy atmosphere (WHO 2002a). It is an ambitious vehicle capable of addressing the issues recognized and the plausible solutions raised thus far at international meetings held to address environmental risks to children's health, and is one that will allow governments, enterprises, localities, and the international scientific community to continue to address the many difficult environmental health issues facing children throughout the world. A multi-institutional task force has been established to help define priorities and create an action plan for the Alliance. The WHO has set up a website for HECA which contains background information on the initiative and progress made thus far, available at <http://www.who.int/heca/en/>.

Dr. Gro Harlem Brundtland, Director General of the WHO, effectively underscored the critical role that the international community must play in ensuring a healthy future for all the world's children: "The children of today are the adults of tomorrow. They deserve to inherit a safer, more fair, and healthier world. There is no task more important than safeguarding their environment" (WHO 2002a; Appendix 1).

Appendix 1. Bangkok Statement: A Pledge to Promote the Protection of Children's Environmental Health

WE, the undersigned scientists, doctors and public health professionals, educators, environmental health engineers, community workers and representatives from a number of international organizations, from governmental and non-governmental organizations in South East Asian and Western Pacific countries, have come together with colleagues from different parts of the world from 3 to 7 March 2002 in Bangkok, Thailand, to commit ourselves to work jointly towards the promotion and protection of children's health against environmental threats.

Worldwide, it is estimated that more than one-quarter of the global burden of disease (GBD) can be attributed to environmental risk factors. Over 40% of the environmental disease burden falls on children under 5 years of age, yet these constitute only 10% of the world population. The environmental burden of paediatric disease in Asia and the Pacific countries is not well recognized and needs to be quantified and addressed.

WE RECOGNIZE, that a growing number of diseases in children have been linked to environmental exposures. These range from the traditional waterborne, foodborne and vector-borne diseases and acute respiratory infections to asthma, cancer, injuries, arsenicosis, fluorosis, certain birth defects and developmental disabilities. That environmental exposures are increasing in many countries in the region; that new emerging risks are being identified; and that more and more children are being exposed to unsafe environments where they are conceived and born, where they live, learn, play, work and grow. Unique and permanent adverse health effects can occur when the embryo, fetus, newborn, child and adolescent (collectively referred to as "children" from here onwards) are exposed to environmental threats during early periods of special vulnerability. That in developing countries the main environmental health problems affecting children are exacerbated by poverty, illiteracy and malnutrition, and include: indoor and outdoor air pollution, lack of access to safe water and sanitation, exposure to hazardous chemicals, accidents and injuries. Furthermore, as countries industrialize, children become exposed to toxicants commonly associated with the developed world, creating an additional environmental burden of disease. This deserves special attention from the industrialized and developing countries alike. That environmental hazards arise both from anthropogenic and natural sources (e.g., plant toxins, fluoride, arsenic, radiations), which separately and in combination can cause serious harm to children. That restoring and protecting the integrity of the life-sustaining systems of the earth are integral to ensuring children's environmental health now and in the future. Therefore, addressing global changes such as human population growth, land and energy use patterns, habitat destruction, biodiversity loss and climate change must be part of efforts to promote children's environmental health. That despite the rising concern of the scientific community and the education and social sectors about environmental threats to children's health and development, progress has been slow and serious challenges still remain.

That the health, environment and education sectors must take concerted action at all levels (local, national, global), together with other sectors, in serious efforts to enable our countries to assess the nature and magnitude of the problem, identify the main environmental risks to children's health and establish culturally appropriate monitoring, mitigation and prevention strategies.

WE AFFIRM, that the principle "children are not little adults" requires full recognition and a preventive approach. Children are uniquely vulnerable to the effects of many chemical, biological and physical agents. All children should be protected from injury, poisoning and hazards in the different environments where they are born, live, learn, play, develop and grow to become the adults of tomorrow and citizens in their own right. That all children should have the right to safe, clean and supportive environments that ensure their survival, growth, development, healthy life and well-being. The recognition of this right is especially important as the world moves towards the adoption of sustainable development practices.

That it is the responsibility of community workers, local and national authorities and policy-makers, national and international organizations, and all professionals dealing with health, environment and education issues to ensure that actions are initiated, developed and sustained in all countries to promote the recognition, assessment and mitigation of physical, chemical and biological hazards, and also of social hazards that threaten children's health and quality of life.

WE COMMIT OURSELVES, to developing active and innovative national and international networks with colleagues, in partnership with governmental, non-governmental and international organizations for the promotion and protection of children's environmental health, and urge WHO to support our efforts in all areas, especially in the following four:

1. **PROTECTION AND PREVENTION**—*To strengthen existing programmes and initiate new mechanisms to provide all children with access to clean water and air, adequate sanitation, safe food and appropriate shelter:*
 - Reduce or eliminate environmental causes and triggers of respiratory diseases and asthma, including exposure to indoor air pollution from the use of biomass fuels and environmental tobacco smoke.
 - Reduce or eliminate exposure to toxic metals such as lead, mercury and arsenic, to fluoride, and to anthropogenic hazards such as toxic wastes, pesticides and persistent organic pollutants.
 - Reduce or eliminate exposure to known and suspected anthropogenic carcinogens, neurotoxicants, developmental and reproductive toxicants, immunotoxicants and naturally occurring toxins.
 - Reduce the incidence of diarrheal disease through increased access to safe water and sanitation and promotion of initiatives to improve food safety.
 - Reduce the incidence of accidents, injuries and poisonings, as well as exposure to noise, radiation, microbiological and other factors by improving all environments where children spend time, in particular at home and at school.
 - Commit to international efforts to avert or slow global environmental changes, and also take action to lessen the vulnerability of populations to the impact of such changes.
 2. **HEALTH CARE AND RESEARCH**—*To promote the recognition, assessment and study of environmental factors that have an impact on the health and development of children:*
 - Establish centres to address issues related to children's environmental health.
 - Develop and implement cooperative multidisciplinary research studies in association with centres of excellence, and promote the collection of harmonized data and their dissemination.
 - Incorporate children's environmental health into the training for health care providers and other professionals, and promote the use of the environmental history.
 - Seek financial and institutional support for research, data collection, education, intervention and prevention programmes.
 - Develop risk assessment methods that take account of children as a special risk group.
 3. **EMPOWERMENT AND EDUCATION**—*To promote the education of children and parents about the importance of their physical environment and their participation in decisions that affect their lives, and to inform parents, teachers and caregivers and the community in general on the need and means to provide a safe, healthy and supportive environment to all children:*
 - Provide environmental health education through healthy schools and adult education initiatives.
 - Incorporate lessons on health and the environment into all school curricula.
 - Empower children to identify potential risks and solutions.
 - Impart environmental health expertise to educators, curriculum designers and school administrators.
 - Create and disseminate to families and communities culturally relevant information about the special vulnerability of children to environmental threats and practical steps to protect children.
 - Teach families and the community to identify environmental threats to their children, to adopt practices that will reduce risks of exposure and to work with local authorities and the private sector in developing prevention and intervention programmes.
 4. **ADVOCACY**—*To advocate and take action on the protection and promotion of children's environmental health at all levels, including political, administrative and community levels:*
 - Use lessons learned to prevent environmental illness in children, for example by promoting legislation for the removal of lead from all gasoline, paints, water pipes and ceramics, and for the provision of smoke-free environments in all public buildings.
 - Sensitize decision-makers to the results of research studies and observations of community workers and primary health care providers that need to be accorded high priority to safeguard children's health.
 - Promote environmental health policies that protect children.
 - Raise the awareness of decision-makers and potential donors about known environmental threats to children's health and work with them and other stakeholders to allocate necessary resources to implement interventions.
 - Work with the media to disseminate information on core children's environmental health issues and locally relevant environmental health problems and potential solutions.
- For all those concerned about the environmental health of children, the time to translate knowledge into action is now.

Appendix 2. Relevant Organizations, with Locations and Websites

Association of Southeast Asian Nations (ASEAN). Secretariat in Jakarta, Indonesia.
<http://www.aseansec.org/>

Centers for Disease Control and Prevention (CDC). Atlanta, Georgia, USA.
<http://www.cdc.gov/>

Chulabhorn Research Institute. Bangkok, Thailand.
http://www.cri.or.th/cri/general/gen_res.htm

The G8.
<http://www.g8.utoronto.ca/>

International Research and Information Network on Children's Health, Environment and Safety (INCHEs). The Netherlands.
<http://www.inchesnetwork.org/index/html>

National Institute of Environmental Health Sciences (NIEHS). Research Triangle Park, North Carolina, USA.
<http://www.niehs.nih.gov/>

National Poison Control Center of Malaysia. Penang, Malaysia.
<http://www.prn2.usm.my>

Pan American Health Organization (PAHO). Washington, DC, USA.
<http://www.paho.org/>

Population Services International (PSI). Washington, DC, USA.
<http://www.psiwash.org>

Southeast Asia Tobacco Control Alliance. Bangkok, Thailand.
<http://www.tobaccofreeasia.net>

Sulabh International Institute of Health and Hygiene (SIHH). New Delhi, India.
<http://www.sulabhinternational.org/>

United Nations Industrial Development Organization (UNIDO). Vienna, Austria.
<http://www.unido.org/>

U.S. Environmental Protection Agency (U.S. EPA). Washington, DC, USA.
<http://www.epa.gov/>

World Health Organization (WHO). Geneva, Switzerland.
<http://www.who.int/>

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