# Children's Environmental Health at CDC

## *La salud ambiental de los niños en los CDC*

## *A saúde ambiental das crianças nos CDC*

**Resumen***

La salud ambiental de los niños es un tema de gran relevancia porque la morbilidad y mortalidad relacionadas con exposiciones ambientales son más importantes en este sector de la población (un tercio del global de la carga de enfermedad entre los niños, según la OMS) y porque los niños tienen una particular vulnerabilidad relacionada con factores fisiológicos y con sus patrones de comportamiento. También los determinantes sociales y los factores que determinan la desigualdad entre diferentes comunidades tienen una especial importancia en la vulnerabilidad de los niños ante los factores de riesgo ambiental.

Son varias las áreas de trabajo del Centro Nacional de Salud Ambiental de los Centros para el Control y Prevención de Enfermedades que tienen el interés centrado en la salud ambiental y los niños. Entre ellas, se encuentran la evaluación de la exposición y la biomonitorización; la contaminación atmosférica y el asma; el agua, el saneamiento y la higiene; la prevención de la intoxicación por plomo o las viviendas saludables.

El abanico de temas que están relacionados con la salud ambiental de los niños es amplio y de naturaleza compleja en todo el mundo. Específicas exposiciones prenatales y en la infancia a contaminantes ambientales pueden resultar con efectos adversos en la salud tanto en la infancia como a lo largo del resto de la vida. Algunas exposiciones a contaminantes tóxicos han sido bien estudiadas, pero otras permanecen desconocidas en lo que respecta a los posibles efectos específicos en niños. Queda también mucho trabajo por hacer en lo relativo a vivienda, saneamiento y condiciones higiénicas a lo largo de todo el mundo. Por otro lado, se hace hincapié en que para reducir la carga de morbilidad y mortalidad ambiental para los niños se requiere un enfoque multidisciplinario.

**Resumo**

A saúde ambiental das crianças é um tema de grande relevância porque a morbilidade e mortalidade relacionadas com exposições ambientais são mais importantes neste grupo da população (um terço da carga global das doenças nas crianças, segundo a OMS) e porque as crianças têm uma particular vulnerabilidade relacionada com os fatores fisiológicos e com os seus padrões de comportamento. Também os determinantes sociais e os fatores que determinam as desigualdades entre diferentes comunidades têm uma especial importância na vulnerabilidade das crianças aos fatores de risco ambiental.

São várias as áreas de trabalho do Centers for Disease Control and Prevention (CDC)'s National Center for Environmental Health que se focam na saúde ambiental e nas crianças. Entre elas encontram-se a avaliação da exposição e a biomonitorização; a contaminação atmosférica e a asma; a água, o saneamento e a higiene; a prevenção da intoxicação por chumbo e a habitação saudável.

O leque de temas que estão relacionados com a saúde ambiental das crianças é amplo e de natureza complexa a nível mundial. Exposições específicas pré-natais e na infância a contaminantes ambientais podem resultar em efeitos adversos para a saúde, tanto na infância como durante toda a vida. Algumas exposições a poluentes tóxicos têm sido bem estudadas contudo outras permanecem desconhecidas no que respeita aos seus efeitos específicos nas crianças. Igualmente, existe ainda muito trabalho a desenvolver em todo o mundo relativamente à habitação, ao saneamento e às condições de higiene. Não obstante, sublinha-se que para reduzir a carga de mortalidade e morbidade ambiental nas crianças é imprescindível uma abordagem multidisciplinar.

* Por deferencia con los lectores mayoritarios de RSA y debido al interés de este editorial, los editores hemos incluido un resumen del mismo en español y en portugués.

## I. Overview of children's environmental health

Children and adults come into contact with numerous chemical and other hazardous exposures from environmental sources in their neighborhoods, homes, schools, and places of work. Children's environmental health is a topic of global relevance, as morbidity and mortality resulting from environmental exposures are high and children have particular vulnerabilities due to their physiology and behavior patterns. According to the World Health Organization (WHO), one-third of the global burden of disease among children is a result of modifiable environmental risk factors, with some of the most prevalent environmentally-related health outcomes in children being lower respiratory infections, diarrheal disease, and unintentional injuries[1]. Toxic exposures to chemicals, metals, and other hazardous substances may uniquely impact children and may result in adverse health consequences throughout the lifespan[2,3]. Environmental factors including air pollution, water access and contamination, poor sanitation and hygiene, housing design, and road infrastructure have also been associated with non-communicable diseases in children including asthma, chronic obstructive pulmonary disease (COPD), developmental delay, and injuries[1].

Children are uniquely at risk for experiencing health outcomes related to environmental exposures due to a combination of behavioral and physiological characteristics. Children and infants consume more food per unit body weight than do adults, and children exhibit hand-to-mouth and crawling behaviors which lead to increased exposures as a result of ingestion of contaminants from dust, soil, and contact surfaces[2,4]. Prenatal exposure may occur when chemicals such as lead or mercury cross the placenta, and infants may be exposed to various environmental contaminants (including DDT, PCBs, dioxins and methylmercury) through breastfeeding[4,5]. In addition, children are still developing physiologically and experience "critical windows of vulnerability" during which time exposures may harm body functions and structures more than they would in an adult[4]. Maturation processes such as neurologic, cognitive, and pubertal development may be irreversibly altered if they are disrupted.

The impact of childhood exposures to environmental contaminants may carry over into adult life. Adverse health consequences related to these exposures can manifest in different organ systems and in disparate ways, including neurologic dysfunction and impairment, reproductive abnormalities, immune system dysfunction, and cancer[6]. For example, obesity in later life may be associated with early exposure to environmental chemicals referred to as obesogens[7]. Some of these same chemicals can also increase insulin resistance leading to type 2 diabetes. The link between obesity and diabetes as well as other chronic diseases, such as cardiovascular disease, demonstrates the potential impact of childhood exposure on disease and dysfunction in the adult[6,7].

A range of social determinants may also contribute to certain individual and population health outcomes as well as disparities within and between communities and countries[8]. Individuals from households with higher levels of education, higher income, a living situation that includes safe homes and neighborhoods, and access to preventive health services tend to be healthier throughout their lives[8]. Low-income housing and homes in resource-poor countries may have structural deficiencies, inadequate water and sanitation conditions, lead contamination, and poor indoor air quality as a result of excess moisture, mold, and unclean cookstoves[8,9]. Lead poisoning and asthma exacerbation provide examples of health outcomes with strong social determinants, as they are more common in low- and lower-middle income communities and countries, more prevalent in adults who didn't graduate high school than adults who graduated high school or college, and twice as common among black children than white children in the United States (US)[10-12].

Described below are several program areas within the Centers for Disease Control and Prevention (CDC)'s National Center for Environmental Health that include a focus on children's environmental health as part of CDC's public health mission.

## II. Exposure assessment and biomonitoring

To determine the potential health outcomes associated with childhood exposure to environmental contaminants, it is necessary to quantify and assess levels of exposure. Various approaches are available to assess exposures to environmental contaminants, including collecting information from individuals (surveys), measuring chemicals in food, air, water, or soil (environmental monitoring), measuring chemicals in the immediate vicinity of individuals (personal monitoring), and measuring chemical concentrations in people (biomonitoring). These different approaches to exposure assessment can be used together to reduce the limitations inherent in each approach. In particular, biomonitoring may be used in conjunction with information about suspected sources of environmental contamination to enhance exposure assessments. Biomonitoring can also be useful in environmental epidemiologic research to

evaluate the association between exposures and health outcomes.

CDC conducts biomonitoring in the US by measuring environmental chemicals, their metabolites, or specific reaction products in human specimens, usually blood or urine. Biomonitoring can provide valuable information about the internal dose or body burden of a chemical. A biomonitoring measurement integrates all sources of exposure and all routes of exposure to a chemical, serving as an indicator of total or overall exposure[13]. For example, measurement of urinary cadmium integrates exposure from dietary sources and cigarette smoking, which are the two major non-occupational sources of cadmium exposure in the US population[14].

CDC's Environmental Health Laboratory also develops new laboratory methods and provides technical assistance, training, and technology transfer to state public health laboratories. Since 1999, blood and urine samples collected as part of the National Health and Nutrition Examination Survey (NHANES) have been analyzed for environmental chemicals[13]. However, NHANES specimen collections largely exclude younger children, with urine collection beginning at age six years, and except for blood metals and serum cotinine, blood sampling beginning at age 12 years. By means of numerous collaborations with external partners, the CDC Laboratory provides additional biomonitoring measurements in exposures and health effects studies of children and adults. A notable collaboration has been with the National Children's Study, a pilot study that includes measurement of environmental chemicals in blood and urine from a sample of third trimester pregnant women and in cord blood and urine from a sample of infants[15].

## III. Air pollution and asthma

Both household and ambient air pollution are important sources of environmental exposure that have been linked to a variety of health outcomes in children as well as adults. Household air pollution (HAP) exposure has been associated with diseases including COPD, lung cancer, tuberculosis, asthma, and cardiovascular disease[16-18]. Nearly 3 billion people worldwide use solid biomass as their main fuel source for heating, cooking, and lighting on traditional cookstoves. The 2012 Global Burden of Disease Report listed household air pollution exposure as a major cause of global mortality, with approximately 2 million deaths per year attributable to HAP[19]. In an effort to reduce the burden of HAP-related health outcomes, CDC joined the Global Alliance for Clean Cookstoves as a founding member in 2009 to support the introduction and evaluation of clean and safe cooking. CDC works closely with WHO and health sector partners in priority countries including Kenya, Guatemala, and India to define and evaluate effective cooking solutions that benefit the health of the population.

The Air Pollution and Respiratory Disease Branch of CDC's National Center for Environmental Health conducts surveillance and epidemiologic assessment related to asthma in the United States. Asthma is a chronic inflammatory condition of the airways which may be unusually sensitive to a wide range of stimuli including exercise, cold air, allergens, environmental tobacco smoke, or air pollution[20-22]. Asthma symptoms include repeated episodes of wheezing, breathlessness, and chest tightness. Asthma attacks occur from the narrowing of airways. In the US, the proportion of people with asthma increased nearly 15 % in the last decade[23]. In 2010, it was estimated that 18.7 million adults (one in 12) and 7 million children (one in 11) had asthma and nine people died from asthma every day[23]. There are several environmental factors that have been proposed to account for the increased prevalence of asthma in US children. Air pollution exposure (including environmental tobacco smoke) plays a well-documented role in asthma attacks and exacerbations in those who already have asthma. There is a large body of epidemiologic research that has examined the impact of indoor and outdoor air pollutants, such as particulate matter and ozone, on respiratory health. Increased symptoms of asthma have been associated with elevated air pollution levels[24-29]. The role that air pollution plays in initiating asthma, however, is not well understood; it is believed to involve a complex set of interactions between indoor and outdoor environmental conditions and genetic factors[30-34]. As the scientific understanding of susceptibility to air pollutant effects develop, the findings may help to inform the development of interventions for air pollution-induced asthma.

## IV. Water, sanitation, and hygiene

CDC has a number of programs focused on global access to safe water, adequate sanitation, and hygiene in an effort to reduce morbidity and mortality. Diarrheal diseases are the second leading cause of death worldwide for children under five[35]. Up to 88 % of deaths due to diarrhea are attributed to inadequate water, sanitation, and hygiene conditions[36,37]. Globally, 780 million people lack access to improved water sources and 2.5 million lack access to improved sanitation facilities[38]. Although the majority of this underserved population is concentrated in Africa and Asia, challenges remain in Latin America and the Caribbean, where approximately 118 million persons

live without improved sanitation, and 35 million get their drinking water from unimproved sources[38].

Improving operation and maintenance of water and sanitation facilities is critical to sustaining access to clean water. One tool for improving water quality is WHO's Water Safety Plan (WSP) process for assessing and managing risk in drinking water systems[39]. With regional and local partners, CDC has implemented pilot WSPs in Brazil, Bolivia, Peru, Ecuador, Guyana, Jamaica, and St Lucia. Successful outcomes from these WSPs have included reduced water treatment costs, improved partnerships between water utilities and regulators, and, in the case of Brazil, a requirement for incorporating WSPs into national drinking water regulations. Water, sanitation, and hygiene are critical issues in higher-income countries as well, and CDC provides surveillance, technical and outbreak assistance, and monitoring and evaluation related to water quality, sanitation, and hygiene in the US.

## V. Lead poisoning prevention

Childhood exposure to lead can affect nearly every system in the body, in particular causing irreversible damage to the developing brain and nervous system. Even small increases in blood lead level can result in measurable decreases in IQ[40,41]. At low levels of lead exposure (< 10 µg/dL), negative health effects may also be seen in the immune, reproductive, and cardiovascular systems[42]. No safe blood lead level has been identified in children, and the CDC recommends keeping children's blood lead levels as low as possible. CDC has recently adopted a reference level using the 97.5$^{th}$ percentile for children ages 1-5 years of age from the two most recent NHANES survey periods; currently, this reference level is 5 µg/dL and CDC recommends keeping children's blood lead below this level. CDC also recommends that the most effective way to prevent children from suffering the lifelong consequences of lead exposure is by controlling or eliminating lead hazards in the environment[43].

Over the course of the last 50 years, great strides have been made in reducing blood lead levels in US children as a result of an intense and coordinated effort by government officials, health care and social service providers, and the communities most at risk[44]. Removing lead from gasoline, residential paints, and other consumer products, as well as reducing lead levels in air, house dust, soil, and water has proven not only effective but also cost-efficient. Each dollar invested in lead hazard control is estimated to result in $17-$221 in savings due to increased productivity and reduced medical care, special education and criminal justice costs making lead hazard control comparable to vaccination for common childhood diseases in terms of return on investment[45]. Despite recent successes in lead poisoning prevention, an estimated 535,000 US children still have blood lead levels ≥ 5 µg/dL, with clear disparities between different socio-economic and racial groups[12].

The near elimination of lead in gasoline globally has reduced blood lead levels in children worldwide. Today, the most concentrated and common sources of lead for children in developing countries are mining and processing of metal ores without control for exposures, informal sector recycling of batteries and electronic equipment, certain consumer products including toys and jewelry containing leaded paint, and contamination or adulteration of medicines and teas[46]. Some countries with developing economies have also seen the emergence of residential lead-based paints. As a result of lead exposures from these sources, children in the developing world continue to suffer high levels of lead-related morbidity and mortality[47]. The United Nations Environmental Program and WHO have initiated a global partnership to eliminate residential lead paint by 2020 through a series of voluntary and regulatory strategies and an emphasis on cost-neutral, readily available alternatives. Childhood lead poisoning is a preventable disease globally and the return on investing in childhood lead poisoning prevention efforts is great.

## VI. Healthy homes

CDC's Healthy Homes program takes a comprehensive approach to addressing multiple features of the home environment that may be associated with health outcomes in children. Housing is a critical aspect of environmental health, and children living without a home or in an unhealthy home environment are at increased risk for negative health consequences[48]. A healthy home is sited, designed, built, renovated, and maintained in ways that support the health of residents. Specific features that determine the health of a home include structural and safety aspects, indoor air and water quality, and the presence of toxic chemicals. The surrounding neighborhood and community are also important aspects of healthy homes. Many hazards can affect everyone regardless of socioeconomic status. Secondhand smoke; exposure to chemicals such as pesticides and some household cleaning products; allergens such as dust mites; fire and burn hazards; and fall hazards such as clutter and poor lighting can be found in many homes and neighborhoods. These hazards may result in a multitude of health effects including poisonings, fire and fall-related injuries, and lung diseases such as asthma and cancer[49]. Some hazards

are more common in certain geographic locations. For example, radon gas levels and the potential for extreme weather conditions and disasters vary across the United States and throughout the world[50,51].

An expert panel, sponsored by CDC and the National Center for Healthy Housing, conducted a systematic review of housing interventions and health and determined that there is sufficient evidence of effectiveness for a number of interventions. These include reduction of interior allergens through multifaceted in-home interventions for asthma; elimination of moisture intrusion and leaks and removal of moldy items; use of integrated pest management to reduce both pests and insecticides; reduction of toxic chemicals through smoke free rules; lead hazard control and active radon air mitigation; use of safety devices such as installed working smoke alarms, four sided pool enclosures, and preset temperatures on water heaters; and use of rental vouchers to help families afford safe and sanitary housing[52]. The costs and benefits of these interventions have been considered, and the US Surgeon General suggests that implementing these would have a direct and measurable effect on the public's health[48].

## VII. Conclusion

As evidenced by the variety of CDC efforts described above, the range of issues pertaining to children's environmental health around the world is broad and complex in nature. Specific prenatal and childhood exposures to environmental contaminants may result in adverse health effects both during childhood and later in life. While certain exposures such as lead are well-studied and understood, much remains unknown about the specific effects of chemicals and other toxic environmental exposures on children. Additional research is needed to further scientific understanding of environmental exposures, and work remains to improve housing, water, sanitation, and hygiene conditions throughout the world.

Reducing the burden of environmental morbidity and mortality for infants and children requires a multi-disciplinary approach. Integrating preventive measures such as better understanding of exposures in children (including appropriate biomonitoring), environmental remediation, behavior change, and policy implementation in a population is critical. There is a need for partnership and collaboration between public health practitioners, physicians and nurses, policy makers, educators, non-governmental organizations, and communities to define and implement changes necessary to effectively address children's environmental health issues.

**Lindsey M. Horton[a], Paula Burgess[a], Yulia Iossifova[a], Mary Jean Brown[b], Mary E. Mortensen[c], Fuyuen Yip[d], Rick Gelting[b], Brian Hubbard[b], and Vikas Kapil[a]**

[a] Office of Science, National Center for Environmental Health and Agency for Toxic Substances and Disease Registry, 4770 Buford Highway, Atlanta, GA, 30341
[b] Division of Emergency and Environmental Health Services, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Highway, Atlanta, GA, 30341
[c] Division of Laboratory Sciences, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Highway, Atlanta, GA, 30341
[d] Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Highway, Atlanta, GA, 30341

*The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Agency for Toxic Substances and Disease Registry*

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