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Reducing The Staggering Costs Of Environmental Disease In Children, Estimated At $76.6 Billion In 2008

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Abstract

A 2002 analysis documented $54.9 billion in annual costs of environmentally mediated diseases in US children. However, few important changes in federal policy have been implemented to prevent exposures to toxic chemicals. We therefore updated and expanded the previous analysis and found that the costs of lead poisoning, prenatal methylmercury exposure, childhood cancer, asthma, intellectual disability, autism, and attention deficit hyperactivity disorder were $76.6 billion in 2008. To prevent further increases in these costs, efforts are needed to institute premarket testing of new chemicals; conduct toxicity testing on chemicals already in use; reduce lead-based paint hazards; and curb mercury emissions from coal-fired power plants.

Children's Health | Chronic Care | Environmental Health | Health Economics | Public Health

In 2002 Philip Landrigan and colleagues estimated the annual costs for four chronic childhood conditions—lead poisoning, childhood cancer, developmental disabilities, and asthma—that could be attributed to environmental factors. The authors found that these costs totaled $54.9 billion in 1997 dollars, or 2.8 percent of US health care costs in 1997.[1] The intent of this analysis was to inform decisions by policy makers to allocate sufficient resources toward prevention of exposures to lead, methylmercury (a form of mercury that has been found to be harmful to the developing brain), certain pesticides, and outdoor air pollutants that are hazardous to children's learning and development.

In the years since that analysis was completed, legislative efforts have failed to update the 1973 Toxic Substances Control Act to require that chemicals be tested for their toxicity, especially in children and other vulnerable populations, before they are approved by the Environmental Protection Agency (EPA) for widespread use.[2] The result is that newly produced chemicals lead to health effects that gain little attention, until studies identify the impact and drive regulatory action that leads to limits on their ongoing use. Many companies have committed to helping fill toxicity testing gaps for chemicals produced in the largest volumes. However, in six years the EPA has completed reviews of only six chemicals through its Voluntary Children's Chemical Evaluation Program.[3]

Federal policy action to limit children's exposure to known chemical hazards has also been extremely limited. Funding for lead-hazard control programs did not meet levels projected to be necessary for eliminating childhood lead poisoning by 2010.[4] Regulations intended to undermine restrictions on mercury emissions from coal-fired power plants set by the Clean Air Act were [5]

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overturned by a federal circuit court ruling in 2008. Although the EPA recently released a plan proposing national emission standards for hazardous air pollutants from coal- and oil-fired electric-utility steam-generating units, progress in limiting emissions of mercury from coal-fired power plants has been severely delayed.[6] What's more, the National Ambient Air Quality Standards still do not adequately protect children from the respiratory effects of outdoor air pollutants.[7]

Other events also suggest a need to refresh those 2002 cost estimates to reflect current conditions. Reductions in childhood blood lead levels[8] and particulate-matter air pollution, which has been associated with asthma exacerbations,[9,10] may have reduced economic costs that contributed heavily to previous estimates.[11] In addition, management of childhood asthma increasingly relies on relatively inexpensive outpatient care rather than inpatient care.[12] However, evidence for the role of chemical factors in chronic childhood conditions has only increased and now includes attention deficit hyperactivity disorder.[13-15] Estimates of lost economic productivity and intellectual disability associated with mercury pollution have also been completed since the 2002 estimates of annual costs for childhood conditions that could be attributed to environmental factors.[16,17]

We therefore gathered new estimates for the economic consequences of diseases of environmental origin in children. The analysis was broadened to include additional exposures and outcomes, such as prenatal methylmercury exposure and attention deficit hyperactivity disorder.

Study Data And Methods

We limited our analysis, as Landrigan and colleagues did, to those diseases in childhood associated with "chemical substances of human origin in environmental media—air, food, water, soil, the home, and the community," and we excluded drugs and social or physical environmental factors.[1] We chose to exclude cerebral palsy in our analysis (although Landrigan and others included this condition in their analysis) because of the relative paucity of evidence to support chemical risk factors.[18]

To calculate costs, we multiplied an environmentally attributable fraction by the prevalence or incidence (whichever is more appropriate for the condition being examined), the population at risk, and the cost per case. Modeling using environmentally attributable fraction has been used widely. It enables attribution of burden and costs for complex conditions that have multiple interacting origins, such as factors in the social and physical environment.[1,19,20] To quantify attributable fractions for a particular category of risk factors, the prevalence of these risk factors is placed into a formula that accounts for the relative risk of disease associated with the risk factors.[21,22]

The approach taken for each condition when assessing population size, cost per case, and an environmentally attributable fraction is described in greater depth in the Appendix.[23] Selection of disease rate, population at risk, and environmentally attributable fractions for lead poisoning, childhood cancer, asthma, intellectual disability, and autism closely followed the previously published approach.[1] Data sources for these factors are provided in the Appendix.[23] Populations at risk and the environmentally attributable fraction for methylmercury toxicity were also identical to those used by Leonardo Trasande and colleagues.[17] Conversion of prevalence and incidence to the appropriate population size relied on US census estimates for 2008.[24]

For attention deficit hyperactivity disorder, we used the cohort of children born each year as our at-risk population, and we quantified the prevalence among twelve-year-olds of attention deficit hyperactivity disorder diagnosis combined with a prescription for stimulant medication in the most recent year available (from the 2007 National Survey of Children's Health).[25] The environmentally attributable fraction was derived by coupling the most recent available biomarker data on three types of chemical exposures with odds ratios that those exposures would result in a diagnosis of attention deficit hyperactivity disorder.[22]

The biomarker data included childhood lead exposure (2007–08 National Health and Nutrition Examination Survey);[13] perfluorinated chemicals—chemicals that contain fluorine and are used in a large number of household products such as stick- and stain-resistant products (1999–2000 and 2003–04 National Health and Nutrition Examination Survey);[14] or exposures to pesticides based on alkyl phosphates—a type of organic compound (2000–04 National Health and Nutrition Examination Survey).[15]

Additional sources for costs per case and data values are presented in the Appendix.[23] For asthma and childhood cancer, data were from the most recent and nationally representative sources: the Medical Expenditure Panel Surveys; Nationwide Inpatient Sample; Nationwide Emergency Department Survey; and National Hospital Ambulatory Medical Care Survey/National Ambulatory Medical Care Survey. Data from 2006–08 were merged as a proxy for direct medical costs in 2008 and were corrected using the Medical Care Consumer Price Index.[26]

Previously published estimates of per case direct or indirect costs, or both, were used for attention deficit hyperactivity disorder,[27] autism,[28] lead poisoning,[29] and mental retardation.[30] These costs were adjusted to reflect 2008 dollars. Lifetime economic productivity estimates were provided by the University of California, San Francisco, Institute for Health and Aging.[31]

Other indirect costs were included for asthma using data on work days lost from a May 2004 national survey of parents with asthma,[32] and death statistics for children with asthma from the 2007 National Vital Statistics Reports.[33] Lost economic productivity from these sources was derived using data from Wendy Max and colleagues.[31]

Knowledge about the role of chemical factors in childhood disease continues to evolve. As it does, more precise estimates can be made of the health and economic consequences of environmental exposures to children. We examined a range of reasonably possible values that represents the possible economic costs of these diseases that can be attributed to environmental factors. Factors incorporated into this sensitivity analysis included ranges for the percentage of disease that can be attributed to environmental risk factors and per case costs of chronic childhood conditions. The Appendix describes the ranges for possible values and the basis for adopting these ranges for each component of the sensitivity analysis.[23]

All results are presented in 2008 dollars. Statistical analyses were conducted using the statistical software SAS version 9.1.3 and SUDAAN version 9.0.3 to account for the complex sample designs used in the four data sources mentioned above and in the Appendix.

Study Results

For childhood lead poisoning, we identified $5.9 million in medical care costs, as well as an additional $50.9 billion (sensitivity analysis: $44.8–$60.6 billion) in lost economic productivity resulting from reduced cognitive potential from preventable childhood lead exposure. Methylmercury toxicity was found to contribute an additional $5.0 billion in lost economic productivity (sensitivity analysis: $3.2–$8.4 billion). In our base-case analysis, $5.4 billion in intellectual disability costs, $7.9 billion in autism costs, and $5.0 billion in costs for attention deficit hyperactivity disorder could ultimately be attributed to chemical factors in the environment. Our sensitivity analysis found that $11.6–$36.1 billion in economic costs of developmental disabilities could be attributed to hazardous environmental exposures.

We estimated that in 2008, $3.3 billion in direct medical costs and $4.0 billion in indirect costs, such as lost productivity resulting from parents' caring for sick children, could be attributed to asthma. Applying a range of attributable fractions (10–35 percent), the best estimate of childhood asthma costs in 2008 that could be associated with environmental factors was $2.2 billion (sensitivity analysis: $728 million–$2.5 billion). In 2008, $1.9 billion in inpatient, emergency room, prescription drug, and outpatient costs were attributed to children diagnosed with malignancies. Of these, $95.4 million (sensitivity analysis: $38.2–$190.8 million) could be attributed to chemical exposures. Exhibit 1 shows costs attributed to environmental factors for each condition studied.

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Exhibit 1

Aggregate Costs Of Environmentally Mediated Diseases In US Children, 2008

Aggregating the costs of the childhood conditions for which we identified a strong and preventable risk factor in the chemical environment, and using data from the National Health Expenditure Accounts, Centers for Medicare and Medicaid Services, we found that diseases of environmental origin in children cost $76.6 billion, or 3.5 percent of US health care costs, in 2008.[34] Incorporating all of our sensitivity analyses, we estimated a lower bound for these costs of $59.8 billion (or 2.7 percent of US health care costs) and an upper bound of $105.8 billion (or 4.8 percent of US health care costs).

Discussion

Our principal finding is that chemical factors in the environment continue to contribute greatly to childhood morbidity and to health care costs. Between 1997 and 2008, the Consumer Price Index increased by 34.1 percent, and the Medical Care Consumer Price Index increased by 55.2 percent. The majority of the costs aggregated in the 2002 analysis by Landrigan and colleagues were nonmedical costs.

To ensure an accurate comparison, we used both the Consumer Price Index and the Medical Care Consumer Price Index for 1997 and 2008 to compare the results obtained in these two analyses more closely. We found that the estimate of costs in 1997—$54.9 billion in 1997 dollars—would translate to $73.7 billion in 2008 dollars. As a rough comparison, this would suggest that costs of childhood diseases attributable to environmental factors did not increase dramatically.

Comparison to the previous estimate of these costs in this way, however, would be inappropriate, because our analysis includes some conditions newly identified with strong evidence for environmental origins and excludes others. Exhibit 2 attempts to provide a deeper-level comparison of the 1997 and 2008 analyses (published in 2002 and 2011, respectively). For lead poisoning, asthma, intellectual disability, autism, and childhood cancer, costs were lower in the more recent analysis ($66.5 billion in 2008 dollars) compared with 1997 ($71.4 billion in 2008 dollars).

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Exhibit 2

Comparison Of 1997 And 2008 Costs Of Environmentally Mediated Diseases In US Children

Major factors that contributed to reductions in these common costs were diminished childhood lead exposure[8] and a decrease in use of health care services for asthma. Childhood asthma health care costs may have fallen, in part, as a result of nationwide reductions in outdoor air pollution observed between 1990 and 2005 and attributed to the 1990 Clean Air Act, which gave the EPA greater power to reduce emissions from automobiles and other sources.[35,36] A decline in outdoor air pollution probably played a role in decreasing use of health care services for childhood asthma. However, it is important to recognize that at the same time, asthma management shifted to emphasize less costly outpatient management of the condition.[37] Both factors were major contributors to the cost differences we describe here.

Growing Evidence Base

Another theme borne out through comparison of the 2002 and this analysis is that studies continue to unearth increasing evidence that environmental chemicals play an increasing role in childhood disease. Our analysis was highly conservative in that we included only conditions that have the strongest evidence of cause from environmental origins.

Emerging evidence, for example, is beginning to support the notion that endocrine-disrupting chemicals may contribute to the development of childhood obesity.[38,39] Such chemicals are found in the environment, food, or consumer products and interfere with metabolism or normal hormone control or reproduction. A recent analysis found that the cohort of twelve-year olds in 2005 is estimated to incur $3.46 billion in direct medical expenditures during childhood and another $5.60 billion during adulthood (2005 dollars) that are attributable to childhood obesity.[40-42]

If confirmatory evidence supports even 1–3 percent of these costs and consequences to be attributable to chemical factors in the environment, then the estimates obtained here would increase further. Similar comments could be made about cardiovascular risks, which have been associated with perinatal (just before and immediately following birth) exposure to methylmercury.[43,44]

Childhood lead exposure has also been associated with criminal activity including homicides and robberies later in life, which have broader economic consequences.[45] Adult consequences and costs associated with childhood exposures are likely and may dwarf the economic estimates obtained here, because children have many more years of life.

Need For Further Research

Analyses such as ours identify large economic costs that represent only a small portion of actual costs that can be attributed to chemical factors in the environment. These analyses underline the need for further investments in surveillance of chronic childhood conditions and research—such as the National Children's Study—to identify preventable factors.[38,46-49]

In the absence of data to narrowly define relationships between exposures and health effects, estimates of the environmentally attributable fraction for conditions such as developmental disabilities frequently rely upon expert estimates and literature reviews. The approach used for the environmentally attributable fractions for childhood lead exposure, intellectual disability, autism, asthma, and childhood cancer fortunately has a strong foundation. This foundation dates to work described in 1981 by the Institute of Medicine in assessing the proportion of disease of environmental origin in the United States,[20] and it is widely supported.[50,51]

Rising Costs

As gaps in the knowledge of environmental exposures and their role in chronic childhood disease are filled,[52,53] future cost estimates of environmentally mediated diseases in children may also continue to increase. The US regulatory process permits the approval of chemicals without a stringent requirement for toxicity testing data to assess potential risks of exposure to children, pregnant women, and other vulnerable populations.[2] This allows those new chemical exposures, which actually increase risk for chronic childhood disease, to occur in an uncontrolled fashion. A large portion of the costs described in our analysis could have been prevented through proactive screening of the chemicals that are identified as having adverse consequences, as documented in premarket laboratory studies.

Although childhood lead poisoning continues to recede, ongoing efforts are needed to further reduce the associated annual costs of this condition. Multiple studies have documented the highly favorable cost-benefit profile of eliminating lead-based paint hazards.[54,55] Similarly, great economic savings can be achieved by preventing methylmercury contamination of fish, which is the major source of human exposure to this chemical.[16,56,57]

In the United States, the leading source of mercury emissions is coal-fired power plants. Although it will be some years after reductions in emissions that we see proportionate reductions in fish contamination,[58] reducing mercury emissions is an important component of preventing prenatal exposure to methylmercury with its health and human consequences.[59,60] Given evidence that current ambient air quality standards remain insufficiently protective for children,[7] ongoing efforts are needed to reduce outdoor air pollutant emissions and their consequences for children's breathing.

Reductions in morbidity for very costly illnesses do not always lead to great economic benefits, because interventions do not necessarily eliminate all treatments associated with these conditions.[61] However, analyses such as these provide a sense of the scope of possible economic benefits, and they remind policy makers that these economic benefits must be considered alongside the economic costs of pollution prevention.[62] This analysis reemphasizes for policy makers the implications of failing to prevent toxic chemical exposures not only for the health of children but also for the health of our economy.

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ABOUT THE AUTHORS: LEONARDO TRASANDE & YINGHUA LIU

In this issue of *Health Affairs*, Leonardo Trasande and Yinghua Liu update a 2002 study by Philip Landrigan and colleagues of the costs of environmental exposures for children. They find that the costs of ailments stemming from these exposures, such as lead poisoning and childhood cancers, have increased dramatically in recent years—reaching an estimated $76.6 billion in 2008.

Trasande says that he and Liu undertook this updated study because of the absence of any major policy changes in response to the 2002 study. Although the costs of these environmentally induced childhood illnesses generally increased, some costs did dip substantially over the past decade, including those from asthma, Trasande says. He believes that decrease is probably due to policy changes in the 1990s to reduce lead and air pollution exposure. “This is a significant reminder that the rewards of environmental policy changes often continue for generations to come,” he says. Trasande now hopes that this article's findings will spur further policy action and lead to a decline in environmental exposures.

Trasande is both an associate professor and an assistant attending doctor at the Mount Sinai School of Medicine, in New York City. His specialty is preventive medicine and pediatrics. He previously served as the codirector of the Children's Environmental Health Center at Mount Sinai, and he sat on the steering committee of the National Children's Study, sponsored and conducted by the National Institute for Child Health and Human Development, National Institutes of Health. That study is examining the effects of the environment on a group of children from birth to age twenty-one. Trasande received both his medical degree and his master's degree in health care policy from Harvard University.

Liu is an associate scientist at the National Children's Study New York–Northern New Jersey Center. He received his medical degree from Anhui College of Medicine in China and a doctorate in medical sociology from Renmin University of China.

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