An Economic Cost Assessment of Environmentally-Related Childhood Diseases in Maine

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Executive Summary

Children are exposed to a wide range of toxic chemicals on a daily basis that their developing bodies are particularly ill-equipped to manage. Surprisingly little is known about the health effects of the vast majority of the chemicals that currently exist in the environment, and even less is known about the unique susceptibility of children. The changing pattern of childhood illnesses represents a shift from infectious diseases and genetic abnormalities to those of potentially preventable origin. Childhood diseases are now more often the result of a combination of factors, including both environmental triggers and genetic susceptibility. Maine children are no exception to what has been called the "new pediatric morbidity," and suffer from comparatively high rates of asthma and cancer. Maine children are also at an increased risk of lead poisoning due to the aging housing stock and historical industrial activities.

In order to understand the economic impact of environmentally-related childhood diseases in Maine, this report provides a detailed estimate of the annual cost in four broad illness categories: lead poisoning, asthma, childhood cancer, and neurobehavioral disorders. Building upon previous scientific evidence in the health sciences and using state-specific data where available, this report estimates both the number of children suffering from environmentally attributable diseases in the state each year, as well as the economic cost associated with treating these illnesses. Overall, the aggregate annual cost of environmentally attributable illnesses in Maine children is estimated to be $380.9 million per year, ranging between $319.4 and $484.3 million. It is important to note that the economic costs outlined in this report represent preventable childhood illnesses, and as such could be fully avoided if environmental exposures in children were eliminated. It should also be viewed as a conservative estimate of the true burden of environmentally-related childhood diseases since it is limited to a relatively small number of the potential health outcomes associated with environmental exposures. For example, this report does not quantify the impact of adult onset cancers related to childhood exposures, although cancer is known to often endure long latency periods before surfacing. This report also excludes the effects of endocrine disrupting chemicals in our environment that may be associated with congenital abnormalities, lower sperm counts, and gender identity disorder. Much of the science related to environmental pollution is still evolving, and as such it is difficult to identify the range of health outcomes that are the direct result of contact during childhood.

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Introduction

The pattern of pediatric disease in the US has evolved from one primarily driven by infectious agents to those with much more complicated multifactorial origins that include both genetic and environmental causes. Advances in medical technologies that have succeeded in reducing infant mortality rates have been countered in part by the negative health outcomes associated with preventable childhood exposures to environmental pollutants. More than 80,000 synthetic chemical compounds have been created over the past 50 years in the US alone (Goldman and Koduru 2000), and information on the health effects of the vast majority of these chemicals is scarce to non-existent. Reducing childhood exposure to environmental contaminants is important for a number of reasons, not the least of which is that children are unable to make informed decisions to limit their exposure to toxic chemicals. According to a recent EPA report, children are more susceptible than adults to the ill effects of environmental pollutants due to their developing organ systems and small size, as well as their unique activity patterns (crawling and hand to mouth contact) and exposure pathways (breast milk and placenta) (Woodruff et al. 2003).

The economic burden of environmental diseases in Maine children is derived using the research methods outlined in a national study by Landrigan et al. (2002)[1] published in *Environmental Health Perspectives*, the peer-reviewed journal of the National Institute of Environmental Health Sciences. This Maine report follows similar efforts by other states to identify state-level costs of environmentally attributable diseases in children, including Massachusetts (Massey and Ackerman 2003), Washington (Davies 2005), Minnesota (Schuler et al. 2006), and California (University of California 2008). Landrigan applied the most recently available scientific evidence using a formal decision-making process of expert panels to broadly define environmentally attributable costs in four childhood disease categories, which included lead poisoning, asthma, cancer, and neurobehavioral conditions (specifically mental retardation, autism, and cerebral palsy). Although this Maine report closely follows the national approach outlined by Landrigan, it is updated wherever possible with Maine-specific data relevant to the health risks, economic impact, and environmental exposures particular to children in the state, and with more recently available scientific evidence on the topic where available. Briefly, the major changes to the Landrigan approach include the addition of a cost category for ADD/ADHD as a fourth neurobehavioral condition, significant updates to the cost of autism in the neurobehavioral category, and the use of Maine special education data to quantify these specific disability-related costs to the state. Cost data from all sources have been adjusted for inflation to reflect 2008 dollars (US BLS 2008).

The economic cost of environmentally related childhood diseases in Maine is constructed based on estimates of the environmentally attributable fraction (EAF).[2] The EAF represents the best available estimate of the percentage of childhood diseases in Maine (ranging from zero to 100%)

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[1] From this point on, Landrigan et al. (2002) is interchangeably referred to simply as "Landrigan".

[2] The concept of the attributable fraction is based on both the prevalence of exposure to an environmental pollutant (how much contact children have with the pollutant) as well as the health risks associated with such exposures. It applies the following formula, where RR represents the relative risk of disease from exposure to environmental pollutants (Breslow and Day 1980):

$$\text{Environmentally Attributable Fraction} = \frac{\text{Prevalence} * (\text{RR} - 1)}{1 + \text{Prevalence} * (\text{RR} - 1)}$$

that could be prevented by eliminating specific environmental exposures in children. The percentage of childhood disease cases attributable to environmental exposures is combined with information on size of the population at risk, the underlying rate of disease among this population, and the cost per case to estimate the following model of total cost to the state:

Total Costs=Disease rate x EAF x Size of population at risk x Cost per case

In other words, the disease rate and size of the population at risk are combined to provide an estimate of the total number of children suffering from a given disease regardless of the source, which is in turn multiplied by the EAF to determine the number of those cases of environmental origin. This number is then multiplied by the cost per case to provide an overall estimate of the economic burden of childhood diseases attributable to environmental causes in the state.

The size of the relevant population of Maine children at risk is dependent on the individual disease categories and closely follows those identified by Landrigan.

Lead poisoning: incidence of disease in the current birth cohort (under 1)
Asthma: prevalence of disease in the under 18 population
Cancer: incidence of disease in the under 18 population
Neurobehavioral: incidence of disease in the current birth cohort (under 1)

Prevalence is defined as the number of children suffering from an illness, while incidence is the rate at which new cases of the disease develop over a given time period. The difference between these two approaches is relevant to the current report because estimates based on prevalence assume that the current cohort of children with the illness could recover fully once an exposure is removed, while those based on incidence assume a more lasting lifetime impact. For example, reductions in asthma severity would be expected to follow declines in exposure to air pollutants or other respiratory triggers. For this reason, annual cost estimates based on current asthma prevalence in the state is an appropriate measure of disease burden. In contrast, once a child develops a neurological impairment or cancer, the effects are more likely to be felt over a lifetime. For this reason, an approach that quantifies the lifetime cost based on the rate at which new cases develop in the current cohort of at-risk children at current exposure levels is more appropriate. Table 1 below provides the reference to the relevant population statistics used in this report.

Table 1: Size of the Relevant Maine Population At-Risk

	Maine	US	ME share of US population
Number of children (<18)*	281,496	73,652,027	0.0038
Birth cohort** (< 1)	13,944	4,112,052	0.0034

*Source: U.S. Census Bureau: State and County QuickFacts (representing 2006 population estimates)
**Source: National Center for Health Statistics, Martin et al. (representing 2004 population estimates)

Costs of Childhood Lead Poisoning

Lead exposure in children can lead to significant health consequences, including brain and kidney damage, anemia, and death at very high levels of exposure (NRC 1993). In response to these negative health effects, much has been done over the past few decades to reduce lead exposure in children and consequently blood lead levels have declined significantly over this time period (Grosse et al. 2002). However, despite the reductions in lead exposure among children, subtle neurological and cognitive impairments remain at the comparatively low exposure levels observed today.

Although the technical definition of elevated blood lead levels (EBLLs) in children establishes a benchmark of 10 µg/dL, substantial evidence has accrued to suggest that the negative health effects can be seen at even lower levels and that there is no safe amount of lead exposure in children (Landrigan et al. 2002). These small and often difficult to detect changes in cognitive function related to low level lead exposure have been shown to impact school performance, educational attainment, and ultimately the lifetime job prospects and earning potential of exposed children (Grosse et al. 2002). This loss of function has been quantitatively linked to both changes in performance on IQ tests, as well as decreases in the lifetime earning potential for exposed children (Salkever 1995, Canfield et al. 2003).

Risk for Maine children

Children living in old homes are especially susceptible to lead exposure through residual lead paint (air and dust), as well as contaminated water (lead pipes) and soil. According to the CDC (data provided in Table 2), 35.8% of Maine houses were built prior to 1950 at a time when lead paint and piping was commonly used, compared with the national average of 22.3% (CDC 2008a). Also, a recent study of the Portland peninsula provided evidence of urban soil contamination from historical industrial activities as well as residual lead from gasoline and paint sources. The study reported that nearly 100% of the properties sampled in the area had lead concentrations in excess of the EPA recommended public health levels (Wagner and Langley-Turnbaugh 2008). The Maine Childhood Lead Poisoning Prevention Program provided data on the percentage of children tested in the state with elevated blood lead levels (see Table 2). These estimates are slightly lower than those projected by the Lead Poisoning Prevention Branch at the US CDC (CDC 2008b) due to differences in the reporting methods.

Table 2: Elevated Blood Lead Levels (EBLLs) and Pre-1950 Housing Units by County

County	Number Screened*	Number EBLL*	Percent EBLL*	% Pre-1950 Housing Units**
Androscoggin	6,674	149	2.2	41.6%
Aroostook	3,916	10	0.3	39.4%
Cumberland	12,888	173	1.3	36.9%
Franklin	1,828	22	1.2	32.1%
Hancock	2,329	28	1.2	35.4%
Kennebec	6,338	64	1.0	35.3%
Knox	1,549	41	2.6	44.0%
Lincoln	1,088	10	0.9	38.1%
Oxford	4,098	45	1.1	36.8%
Penobscot	8,195	95	1.2	34.6%
Piscataquis	9,68	20	2.1	35.2%
Sagadahoc	1,976	25	1.3	36.5%
Somerset	3,915	44	1.1	34.2%
Waldo	1,699	18	1.1	32.1%
Washington	2,408	26	1.1	38.0%
York	9,616	139	1.4	29.8%
State Average	69,715	913	1.3	35.8%

*EBLLs based on data obtained from ME Childhood Lead Poisoning Prevention Program (2009) for children < 72 months of age (data collected between 2003 and 2007)
**Source: CDC 2008a

Landrigan Cost Method

The Landrigan approach limits the estimation of the economic cost of lead poisoning to the decrease in expected lifetime earnings due to IQ reductions in exposed children. These costs will accrue over a lifetime and will materialize in forgone wages due to decreased mental capacity. This estimate is conservative in that it excludes the cost of testing and treatment, as well as any adult-related diseases associated with exposure. It is important to note that these estimates do not represent actual direct or indirect expenditures for disease treatment and abatement.

- EAF = 100%. Based on the assumption that all cases of lead poisoning are the result of environmental causes.

- Size of population at risk = Defined as incidence in the cohort of 5-year old US children. Based on the assumption that no reduction in exposure or medical treatment would restore mental capacity to children with lead poisoning.

- Disease rate/exposure estimate = National blood lead data from the mid-1990s for 5 year olds (average blood lead level 2.7 µg/dL; Pirkle et al. 1998, CDC 1997).

- Cost per case = Calculated as lost lifetime earnings separately for boys and girls (US BLS 1999). Based on the assumption that each 1 µg/dL of blood lead is associated with a 0.25 decline in IQ points, and that each 1 point decline in IQ is responsible for a 2.39% loss of lifetime earnings (Schwartz et al. 1985; Salkever 1995).

Updated Maine Cost Method

The estimates for the economic burden of disease in Maine children related to lead poisoning closely follows the Landrigan approach described above with the following exceptions.

- Size of population at risk = Defined as incidence in the current Maine birth cohort (<1) as surrogate for Landrigan estimate of 5-year olds. The number of boys and girls extrapolated based on state-level data of the male to female ratio (US Census 2000).
- Disease rate/exposure estimate = National blood lead data updated to 1999-2002 (average blood lead **1.9 µg/dL**; CDC 2005). The national average was used as a surrogate for the Maine-specific data because the state does not currently collect the data necessary to calculate a state-wide average.[3]
- Cost per case = Based on the assumption that each 1 µg/dL of blood lead is associated with a **0.46** decline in IQ points (Canfield et al. 2003). All cost estimates updated to reflect 2008 dollars.

Results

Table 3 provides the results of the total cost calculations for the economic impact of childhood lead exposure in Maine using the updated approach outlined above. The evidence suggests that this year's cohort of children born in Maine can expect to earn nearly $240 million less (in 2008 dollars) throughout their lifetime as a result of the cognitive and neurological deficits related to lead. It is important to note that these costs should be interpreted as the lost value of future wage earnings that accrue over a lifetime. Therefore, they are not representative of direct annual expenditures, but are instead indicative of lost *potential* in the current birth cohort.

Table 3: Total Annual Cost of Childhood Lead Exposure in Maine†

EAF	100%
Main consequence	Loss of IQ over a lifetime
Mean blood lead levels	1.9 µg/dL
Blood lead level of 1 µg/dL	Mean loss of 0.46 IQ points per child
At mean blood levels	Mean loss of 0.874 IQ points per child
Loss of 1 IQ point	Loss of lifetime earnings of 2.39%
At mean blood levels	Loss of 2.09% of lifetime earnings
Economic consequences	
For boys	2.09% x $1,166,057 (lifetime earnings) x 6,791 = $165,500,686
For girls	2.09% x $687,742 (lifetime earnings) x 7,153 = $102,815,847
Total annual cost of childhood lead exposure	**$268,316,533**

†Representing 2008 dollars

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[3] More specifically, blood lead tests that show less than 5 µg/dl are recorded only as "<5 µg/dl", so it would be inaccurate to calculate an overall mean using this information.

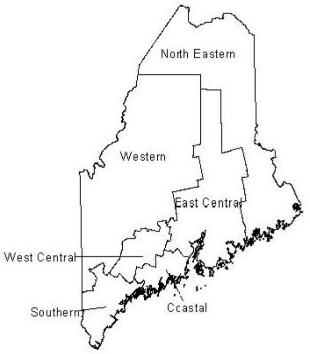
Costs of Childhood Asthma

Asthma is the most prevalent illness in children and the most common cause of childhood hospitalizations (Landrigan et al. 2002). The national rate of asthma among children doubled between the years of 1980 and 1995 (from 3.6% to 7.5%), and is currently estimated to be 8.7% (Woodruff et al. 2003). Exposure to outdoor (Wong et al. 2005) and indoor (NAS 2000a) air pollutants, including household chemical products and pesticides (Sherriff et al. 2005), have been associated with the both the onset and severity of asthma in children. There is also growing evidence to suggest that chronic exposure to air pollutants such as ozone and particulate matter are causally related to decreased lung function and the development in asthma in children (Woodruff et al. 2003).

Risk for Maine children

The prevalence of asthma in Maine children has been increasing in recent years, and is currently estimated at 11.2% (Tippy 2005)[4]. Maine has one of the highest asthma rates in the nation (ranks 5th for adults currently diagnosed with asthma; CDC 2006a). The asthma rate varies across regions of the state (see Figure 1), with estimates ranging from 9.1% in coastal Maine (Knox, Lincoln, Sagadahoc counties), to 14.4% in western Maine (Franklin, Oxford, Piscataquis, Somerset counties). As a reflection of the state burden of asthma care, the prevalence of asthma in the MaineCare population is 15.1% (compared to 9.5% in privately insured children) (Tippy 2005).

Figure 1: Asthma Prevalence by Region of the State

	Current Asthma	
Western	12.8%	
North Eastern	12.8%	
West Central	9.9%	
East Central	14.4%	
Coastal	9.1%	
Southern	9.6%	
State Average	11.2%	
US Average	8.5%	

Source: Tippy 2005

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[4] Prevalence data is based on a state-wide survey of kindergarten and third graders (Tippy 2005). This report assumes that prevalence is uniform across the entire underage population. Due to a low response rate for the survey used, the results cannot be considered to be generalizable beyond the population sampled. However, the results were similar to those provided by national surveys with high response rates of US children under 18 [13% "ever asthma" and 9% "current asthma" (Bloom et al. 2006)], of US high school students [17% "ever asthma" and 14.5% "current asthma" (CDC 2006b)], and of Maine adults [14.1% "ever asthma" 9.7% "current asthma" (CDC 2006a)], as well as a recent asthma report released by the state estimating "current asthma" at 10.7% and "lifetime asthma" at 14.6% (ME CDC 2008).

Landrigan Cost Method

- EAF = 30% (range 10-35%).
- Size of population at risk = Not defined. Estimates based on the aggregate national cost of asthma multiplied by the EAF.

- Disease rate/exposure estimate = Not defined. Estimates based on the aggregate national cost of asthma multiplied by the EAF.

- Cost per case = Aggregate cost of asthma, including asthma-related deaths, developed from existing literature (Chestnut et al. 2000, Weiss et al. 2000). Excludes costs of asthma-related morbidity beyond the age of 18.

Updated Maine Cost Method

The estimates for the economic burden of disease in Maine children related to asthma closely follows the Landrigan approach described above with the following exceptions.

- Size of population at risk = Defined as current prevalence in the cohort of Maine children under the age of 18. Based on the assumption that environmental abatement would be expected to reduce the burden of asthma morbidity.

- Disease rate/exposure estimate = Maine-specific asthma prevalence rate of 11.2%.

- Cost per case = Derived from a recent report detailing the per child cost of asthma in Maine (Davis 2007). Based on the size of the cohort, there is less than one environmentally attributable asthma death per year in Maine so this cost is excluded (CDC 2007a). All cost estimates updated to reflect 2008 dollars.

Results

Table 4 presents an estimate of the total annual economic burden of \$8.8 million (range \$2.9–\$10.3) in environmentally related asthma costs in the state. Over 3,000 children are estimated to be suffering from asthma as a result of non-genetic environmental exposures.

Table 4: Total Annual Cost of Environmentally Attributable Childhood Asthma in Maine[†]

EAF	Expected number of children <18 with asthma	Total number of environmentally attributable cases per year	Total annual treatment cost per case	Total annual cost of environmentally attributable asthma
10%	31,527	3,153	**$931**	$2,934,533
30%	**31,527**	**9,458**		**$8,803,600**
35%	31,527	11,035		$10,270,866

[†] Representing 2008 dollars

Costs of Childhood Neurobehavioral Disorders

Neurobehavioral disorders impact between 3-8% of infants born in the US each year (Landrigan et al. 2002), and 28% of these conditions can be linked either directly or indirectly to environmental factors (NAS 2000b). Of the approximately 80,000 chemicals registered for commercial use with the EPA, over 200 have been shown to have neurotoxic effects in adults (see full list in Table A-1 of Appendix), and a handful of others (lead, methylmercury, polychlorinated biphenyls (PCBs), arsenic, and toluene) have been clinically proven to cause neurodevelopmental disorders in children (Grandjean and Landrigan 2006). However, the size of this list is restricted by a general lack of scientific information on the health effects of most chemicals, and should therefore not be regarded as a comprehensive assessment of the chemicals associated with neurological abnormalities in children. The developing brain is highly susceptible to environmental exposures, much more so than fully formed adult brains. The neurological development process that begins in utero continues after birth, and if any stage of development is impeded during this process, the effects are often permanent. Furthermore, the placenta is not an effective shield against most neurotoxins, and the blood-brain barrier that protects adults is not fully formed until about six months of age (Grandjean and Landrigan 2006).

Risk for Maine children

Over last 10 years, the number of Maine children receiving special education services related to neurological impairment has been increasing, and nearly one in five public school students now receives special education services from the state (D.E. 2008a). The total cost to provide those services has been growing at 6.7% per year, and was estimated to be nearly $300 million in 2006 (D.E. 2008b). Although overall student enrollment has declined, the share of special education students has increased from 12.7% in 1986 to 17.7% in 2007 (D.E. 2008a). Growth in number of special education students categorized as autistic is especially alarming, increasing 58.6% over the last three years of available data (2004-2007) (D.E. 2008c). Table 5 provides a list of special education enrollment in the relevant disability categories.

Table 5: Developmental Disability as a Percentage of Total Enrollment (2006)

Disability Category	Total Number of Students	% of Total Enrollment (n=194,232)
Mental Retardation	798	0.4%
Speech and Language Impairment	8,612	4.4%
Emotional Disability	2,943	1.5%
Other Health Impairment	5,528	2.9%
Specific Learning Disability	10,053	5.2%
Multiple Disabilities	3,082	1.6%
Developmentally Delayed	888	0.5%
Autism	1,990	1.0%
Total	33,894	17.5%

Source: D.E. 2008c

Landrigan Cost Methods

The Landrigan report limited the cost assessment to three neurobehavioral conditions (mental retardation, autism, and cerebral palsy) due to the lack of both incidence and cost data for other neurobehavioral illnesses. Furthermore, although a National Academy of Sciences report (2000) suggested that up to 28% of neurobehavioral disorders could be linked to environmental exposures, Landrigan used a more conservative estimate of 5-20% to exclude cases that could be attributed to substance abuse such as fetal alcohol syndrome. Also, to avoid the potential for double counting children with mental retardation and autism or cerebral palsy, Landrigan imposed a downward adjustment of 34% on attributable cases of autism and 15% on attributable cases of cerebral palsy. Finally, since IQ loss associated with lead exposure is one cause of mild mental retardation in children, they also controlled for lead as a confounding factor with a downward adjustment of 2.5% for the mental retardation category.

- EAF = 10% (range 5-20%). Based on a conservative estimate in order to avoid the inclusion of neurobehavioral conditions related to substance abuse.

- Size of population at risk = Defined as incidence of neurobehavioral diseases in the current national birth cohort (<1). Based on the assumption that environmental cleanup will not improve the health of children already suffering from neurobehavioral disorders.

- Disease rate/exposure estimate = Disease rates for mental retardation, autism, and cerebral palsy taken from a 1991-94 survey (Buxbaum et al. 2000).

- Cost per case = Derived cost estimates from a study limited to mental retardation, autism, and cerebral palsy (Honeycutt et al. 2000).

Updated Maine Cost Method

The estimates for the economic burden of disease in Maine children related to neurobehavioral diseases closely follows the Landrigan approach described above with the following exceptions.

- Special education category added – The line item costs of special education services in the Landrigan study was replaced with a separate Maine-specific category. Total state special education costs in 2006 were reported to be $282,763,474 (D.E. 2008b), which would represent $302,556,917 in 2008 dollars.

- ADD/ADHD category added: Based on a recent meta-analysis of the existing literature (Pelham et al. 2007) outlining the rates of ADD/ADHD in children as well as the cost associated with treatment, a category for this disorder has been added to the economic assessment of neurobehavioral conditions. This study cited a national disease rate of between 2 and 9%, for which this report chooses a mid-range estimate of 5% to represent Maine children. In order to control for co-existing conditions, the same downward adjustment applied to autism cases (34%) is also applied to ADD/ADHD.

  The cost estimate for ADD/ADHD is also provided by the recent literature in this area (Pelham et al. 2007), which calculated the aggregate annual cost of ADD/ADHD minus special education services as $10,730 per year per child. Assuming these costs accrue annually over a 13-year period for school aged children (between 5 and 18 years of age) at a discount rate of 3%, total costs per child during the school age years would be $117,589.

  The cost method for ADD/ADHD is a much more conservative estimate than is applied to the other neurological conditions because it does not account for the lifetime impact of the condition. Although this is certain to underestimate the total economic impact of

ADD/ADHD in Maine, the specific cost data necessary to extend the time period under consideration is not currently available.

- Disease rate/exposure estimate
  - Mental Retardation –Incidence based on the national rate of 12 cases per 1,000 births (Bhasin et al. 2006).

  - Cerebral Palsy –Incidence based on the national rate of 3.6 cases per 1,000 births (Yeargin-Allsopp et al. 2008).

  - Autism –Incidence based on the national rate of 1 in 150 children with autism spectrum disorders (CDC 2007b).

- Cost per case = Based on a more recently available study of the economic impact of autism (Ganz 2007), the costs have been updated to reflect a lifetime impact of approximately $3.5 million per child. This excludes the cost of special education services, which are calculated separately in this report. All cost estimates updated to reflect 2008 dollars.

Results

Table 6 presents an estimate of the total annual economic burden of $101.9 million (range $47.8–$203.4) in environmentally related costs for neurobehavioral conditions in the state. Over $30 million of this total is spent directly by the state on an annual basis on special education services for students with environmentally attributable disabilities.

Table 6: Total Annual Cost of Environmentally Attributable Neurobehavioral Disorders in Maine[†]

	EAF	Mental Retardation*	Cerebral Palsy	ADD/ADHD	Autism
Total environmentally attributable cases per year	5%	9	3	34	5
	10%	**17**	**5**	**67**	**9**
	20%	33	10	134	18
Total lifetime cost per case**		$2,181,456	$1,927,554	$117,589	$3,551,683
Total cost per birth cohort	5%	$12,927,144	$4,915,264	$2,638,697	$11,720,555
	10%	**$36,157,626**	**$8,192,106**	**$5,199,786**	**$21,096,998**
	20%	$71,988,033	$16,384,212	$10,399,571	$42,193,996
Special education expenditures only					
Total annual cost = $302,556,917					
	5%	$15,127,846			
	10%	**$30,255,692**			
	20%	$60,511,383			
Total annual environmentally attributable costs of neurobehavioral disorders					
	5%	$47,329,505			
	10%	**$100,902,207**			
	20%	$201,477,195			

[†] Representing 2008 dollars

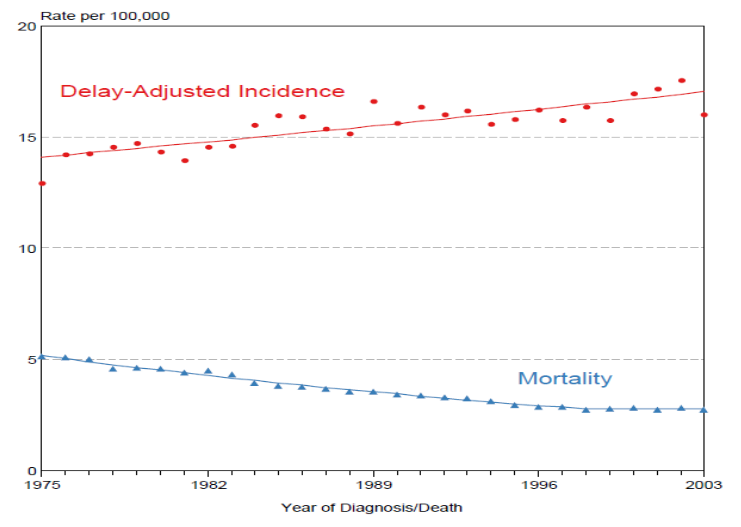
*Annual incident cases for mental retardation adjusted for lead confounding

**Excluding special education services

Costs of Childhood Cancer

Cancer related deaths in children have been declining over the last 20 years due to medical advances in treatment options. However, the same time period has witnessed a troubling increase in the incidence of childhood cancers, which can be seen in national data of incidence and mortality from 1975 to 2003 presented below in Figure 2. There is a great deal of uncertainty on the underlying causes of childhood cancer. While the available evidence suggests that no more than 10-20% can be attributed solely to genetic factors, leaving the remaining 80-90% potentially linked to environmental causes, only a small number of toxic chemicals have been adequately researched and definitively linked to childhood cancers (Landrigan et al. 2002). However, there is growing evidence to suggest an increased risk cancer, especially for leukemia and brain cancers, in children with high pesticide exposures, and a similarly increased risk of cancer in children exposed to certain industrial chemicals (Schuler et al. 2006).

Figure 2: Childhood Cancer Incidence and Mortality (1975-2003)



Source: Taken directly from Ries et al. 2006

Risk for Maine children

Based on unpublished data from 1995 to 2004 made available by the Maine Cancer Registry (Maine Cancer Registry 2009), there are approximately 62 new cases of childhood cancers each year in the state in the under 20 population, with an average of 12 cancer deaths expected annually. More than half of the childhood cancers in Maine can be attributed to leukemia, lymphoma, and cancers of the central nervous system, which correspond with the most frequently occurring childhood cancers nationally (Schuler et al. 2006). The incidence of childhood cancers in Maine over the 10 year period observed was reportedly 186.2 per million children, which is higher than the national rate of 164 per million (Ries et al. 2006). This translates into an additional six childhood cancers in the state each year when compared with the national rate. The elevated incidence of cancer among children is not surprising given that Maine has the highest incidence of adult cancer in the nation (526.1 per million compared to 458.2 per million nationally; NCI 2009).

Landrigan Cost Methods

- EAF = 5% (range 2-10%). Based on the assumption that a more conservative EAF would account for the uncertainty in the underlying causes of childhood cancer. This estimate conservatively excludes the impact of the late onset of adult cancers that are related to previous childhood exposures.

- Size of population at risk = Defined as incidence of childhood cancers in the national cohort of children under the age of 15. Based on the assumption that environmental cleanup will not improve the health of children already suffering from cancer.
- Disease rate/exposure estimate = Estimated disease rates for childhood cancer based on 1993 data (133.3 cases per million children; Zahm and Devessa 1995).
- Cost per case = Derived cost per childhood cancer case to include the cost of care for the initial cancer as well as the additional costs related to the increased probability of a secondary cancer later in life. They also included both lost parental wages and potential lifetime earnings of the child, and total cost per case is estimated to be $840,482 (in 2008 dollars).

Updated Maine Cost Method

The estimates for the economic burden of disease in Maine children related to childhood cancers closely follows the Landrigan approach described above with the following exceptions.

- Size of population at risk = Defined as incidence of childhood cancers in the national cohort of children under the age of 19 because disease rate data was available for the additional years.
- Disease rate/exposure estimate = Updated the disease rate with more recently available state-specific information suggesting the annual childhood cancer incidence is 186.2 per million children (ME Cancer Registry 2009).
- Cost per case = All cost estimates updated to reflect 2008 dollars.

Results

Given the relatively small population size of the state and the generally low probability of cancer, only 52 cancer cases would be expected in any given year at the current national rate of cancer incidence in children 0-18 years of age (see results in Table 7 below). Using the conservative estimate of 5% for the environmentally attributable cases suggests that two of these cancers are caused by environmental exposures annually. At the average cost of treatment, approximately $2.5 million is spent annually on preventable childhood cancers in the state. It is important to note that these figures ignore the potential economic impact of adult cancers that are related to childhood exposures, since many cancers have a long latency period and wouldn't be expected to materialize until much later in life.

Table 7: Total Annual Cost of Environmentally Attributable Childhood Cancers in Maine†

Expected number of childhood cancers per year (<18 population)	EAF	Total environmentally attributable cases per year	Total treatment cost per case	Total annual cost of environmentally attributable childhood cancers
52	2%	1	**$840,482**	$840,482
	5%	**3**		**$2,521,446**
	10%	5		$4,202,410

†Representing 2008 dollars

Conclusion

As shown in Table 8, the aggregate annual cost of environmentally attributable illnesses in Maine children is estimated to be $380.5 million (range $319.4–$484.3 million), with a cost per Maine child of $1,352 (range $1,135–$1,720). Some of these costs represent direct annual expenditures by the state, including the cost of special education services and the medical treatment costs for MaineCare recipients with asthma, cancer, and neurobehavioral conditions. Other costs represent the indirect monetary impact of parental time off work or the reduced lifetime earning potential of exposed children. For this reason, some of the cost would be incurred immediately while some would be expected to accrue over the lifetime of the effected child. However, it is important to note that all of the economic costs outlined in this report represent ***preventable*** childhood illnesses, and as such could be fully avoided if environmental exposures in children were eliminated. Since this report is limited to a small subset of childhood illnesses, the full impact of environmental exposures in Maine children is likely to be much larger.

The current estimates developed for Maine are on par with work done in other states using similar methods. The comparable per child cost (in 2008 dollars) was $1,246 from a Minnesota study (Schuler et al. 2006), $1,015 from a Massachusetts study (Massey and Ackerman 2003), and $1,317 from a Washington state study (Davies 2005).[5,6] The differences are the result of slight changes in methodology based on the scientific data used, as well as differences in the rate of diseases across the different states.

Table 9: Total Annual Cost of Environmentally Attributable Childhood Diseases in Maine†

Childhood Disease Category	Total Cost Estimate	Range of Cost Estimates
Neurobehavioral	$100.9 million	$47.3-$201.5 million
Cancer	$2.5 million	$0.8-$4.2 million
Asthma	$8.8 million	$2.9-$10.3 million
Lead Poisoning	$268.3 million	$268.3 million
Total	$380.5 million	$319.4 - 484.3 million

†Representing 2008 dollars

Recent work has been done in the state to address the growing concern of chemicals in consumer products (ME Task Force 2007), suggesting that a more comprehensive chemicals policy promoting transparency and consumer education is necessary. Although it is beyond the scope of this report to make specific policy recommendations, it is clear that reducing of childhood exposure to environmental pollutants would provide a sizable economic benefit to the state. Beyond the economic impact, the unique susceptibility of children to environmental pollutants and their inability to make informed decisions to limit their risks makes the issue of reducing childhood exposures a moral imperative.

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[5] The state comparisons include only the estimates generated using the "best estimate" EAF under the Landrigan approach, and exclude additional categories reported by some states for adult cancers and birth defects. This report does not include these health outcomes since they do not have established EAFs and were absent from the original Landrigan report. Also, incidence data was requested from the Maine Birth Defects Program but was not available in time for inclusion in this report.

[6] A recent study of childhood costs was also available for California (University of California 2008). However, the calculation methods (disease categories included, etc.) were unavailable and therefore could not be adequately compared with the Maine numbers.

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Appendix

Table A-1: Chemicals Known to be Human Neurotoxins*

Acetone	Dinitrobenzene	Methyl parathion
Acetone cyanohydrin	Dinitrocresol	Methylcyclopentane
Acrylamide	Dinitrotoluene	Methylene chloride
Acrylonitrile	Dinoseb	Methylmercury
Aldicarb	Dioxathion	Mevinphos
Aldrin	Disulphoton	Mexacarbate
Allyl chloride	Edifenphos	Mipafox
Aluminum compounds	Endosulphan	Mirex
Aniline	Endothion	Monocrotophos
Arsenic and arsenic compounds	Endrin	Naled
Azide compounds	EPN	Nickel carbonyl
Barium compounds	Ethiofencarb	Nicotine
Bensulide	Ethion	p-Nitroaniline
Benzene	Ethoprop	Nitrobenzene
1,2-Benzenedicarbonitrile	2-Ethoxyethyl acetate	2-Nitropropane
Benzonitrile	Ethyl acetate	Oxydemeton-methyl
Benzyl alcohol	Ethylbis(2-chloroethyl)amine	Parathion
Bismuth compounds	Ethylene	Pentaborane
Bromophos	Ethylene dibromide	Pentachlorophenol
Butylated triphenyl phosphate	Ethylene glycol	1-Pentanol
Caprolactam	Ethylene oxide	Phenol
Carbaryl	Ethylmercury	p-Phenylenediamine
Carbofuran	Fenitrothion	Phenylhydrazine
Carbon disulphide	Fensulphothion	Phorate
Carbon monoxide	Fenthion	Phosphamidon
Carbophenothion	Fenvalerate	Phosphine
α-Chloralose	Fluoride compounds	Phospholan
Chlordane	Fluoroacetamide	Phosphorus
Chlordecone	Fluoroacetic acid	Polybrominated biphenyls
Chlorfenvinphos	Fonofos	Polybrominated diphenyl ethers
Chlormephos	Formothion	Polychlorinated biphenyls
Chloroform	Heptachlor	Propaphos
Chloroprene	Heptenophos	Propoxur
Chlorpyrifos	Hexachlorobenzene	Propyl bromide
Chlorthion	Hexachlorophene	Propylene oxide
Coumaphos	n-Hexane	Pyridine
Cumene	Hydrazine	Pyriminil
Cyanide compounds	Hydrogen sulphide	Sarin
Cyclohexane	Hydroquinone	Schradan
Cyclohexanol	Isobenzan	Selenium compounds

Cyclohexanone	Isobutyronitrile	Soman
Cyclonite	Isolan	Styrene
Cyhalothrin	Isophorone	Sulprofos
Cypermethrin	Isopropyl alcohol	2,4,5-T
2,4-D	Isopropylacetone	TCDD
DDT	Isoxathion	Tebupirimfos
Decaborane	Lead and lead compounds	Tefluthrin
Deltamethrin	Leptophos	Tellurium compounds
Demeton	Lindane	Tetrachloroethane
Dialifor	Lithium compounds	Tetrachloroethylene
Diazinon	Manganese and manganese compounds	Terbufos
Diborane	Mercury and mercuric compounds	Thallium compounds
Dibromochloropropane	Merphos	Thiram
Dibutyl phthalate	Metaldehyde	Tin compounds
Dichlofenthion	Methamidophos	Toluene
Dichloroacetic acid	Methanol	Toxaphene
1,3-dichloropropene	Methidathion	Tributyl phosphate
Dichlorvos	Methomyl	Trichlorfon
Dieldrin	Methyl bromide	1,1,1-Trichloroethane
Diethylene glycol	Methyl butyl ketone	Trichloroethylene
Diethylene glycol diacrylate	Methyl cellosolve	Trichloronat
Dimefox	Methyl chloride	2,2',2"-Trichlorotriethylamine
Dimethoate	Methyl demeton	Trimethyl phosphate
Dimethyl sulphate	Methyl ethyl ketone	Tri-o-tolyl phosphate
3-(Dimethylamino)-propanenitrile	Methyl formate	Triphenyl phosphate
N,N-Dimethylformamide	Methyl iodide	Vinyl chloride
Dimethylhydrazine	Methyl methacrylate	Xylene

Source: Grandjean and Landrigan 2006

*List excludes drugs, food additives, microbial toxins, snake venoms, and similar biogenic substances