Missouri Department of Health and Senior Services

Website: Health.mo.gov

Asthma & Lead Poisoning in Missouri Children

Economic Burden of the Environment

Environmental Public Health Tracking

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Executive Summary

Childhood diseases and conditions such as asthma and lead poisoning have substantial impacts on families and communities. This report documents the economic cost of these health conditions in Missouri's children attributable to the environment in 2018. This report replicates a method for using quality environmental public health tracking and surveillance data to arrive at the environmentally-related costs of these conditions.

The formula for estimating the economic burden relies on the number of disease cases, cost per case, and the environmentally attributable fraction (EAF), which is the estimated proportion of disease cases thought to be causally associated with environmental risks. Environmental risks for this report include modifiable physical and chemical factors in homes and community environments. Naturally occurring risks such as radon, and lifestyle factors such as secondhand smoke exposure and diet were excluded from the calculations.

About 1 in 11 (8.7%) of children in Missouri aged 0 to 17 years currently have asthma. Although asthma hospitalizations rates have declined 2.5 percent annually among Missouri children (2004-2015), asthma emergency department (ED) visits among children have remained relatively stable. In addition, asthma ED visits showed significant disparities by race, ethnicity, and gender, and across metropolitan regions. Many asthma exacerbations are preventable if asthma is properly managed, including reducing exposure to environmental triggers. It is estimated that 30% of asthma exacerbations are attributable to outdoor air pollution. Using the Centers for Disease Control and Prevention cost calculator and the formula, the total economic burden of childhood asthma in Missouri attributable to the environment was $34.2 million (in 2018 U.S. dollars).

Lead poisoning in children is associated with adverse health effects, including learning impairment, attention deficits, behavioral problems and even death at very high levels. Testing for lead poisoning is important as it often occurs with no identifiable symptoms. The proportion of children 5 years of age or younger with lead poisoning has significantly declined over time in Missouri, from 3.08% in 2000 to 0.41% in 2016. Disparities also exist, with African-American children (1.59, 95% CI 1.53-1.65) having a significantly higher elevated blood lead level than white children (0.31, 95% CI 0.30-0.32) (2006-2015). Approximately 65% of Missouri housing was built before 1978 and may contain some lead-based paint. Lead-based paint and lead contaminated dust are common causes of lead poisoning in children. It is estimated that 100% of lead poisoning cases are attributable to the environment. There is an estimated loss of 0.60 IQ points for every 1 microgram of lead per deciliter of blood (µg/dL). In 2016, about 1,843 Missouri children aged ≤ 5 years had a blood lead level of 5 µg/dL or greater.

The average elevated blood lead level was converted into lost IQ points, then into lost lifetime earnings for boys and girls. As a result, the total annual economic burden of childhood lead poisoning on lifetime earnings in Missouri was $61.6 million (in 2018 U.S. dollars).

Introduction

This report documents the economic costs in Missouri of asthma and lead poisoning in children attributable to the environment for 2018.

Childhood diseases have substantial impacts on families and communities. Several articles and reports have estimated the financial impacts of chronic diseases and developmental disorders in children on families and society.[1-5]

This report focuses on two important environmentally-related health conditions in Missouri's children: asthma and blood lead poisoning. It documents the economic cost of both conditions from current surveillance data and estimates the fraction of the cost that is attributable to environmental causes. It focuses on environmental factors that are amenable to interventions.

To estimate the economic value of preventive actions, this report replicates a method for using quality environmental public health tracking (surveillance) data.[6-7] Using this approach, policy decisions and resources can be directed towards actions that have a measurable impact both in reducing childhood disease and saving money.

The Missouri Environmental Public Health Tracking (MO EPHT) program was established in 2002, when the Centers for Disease Control and Prevention (CDC) first began developing a nationwide environmental public health tracking network. Missouri is part of the larger National Tracking Network that consists of 25 states and one city.[8] In 2016, MO EPHT released environmental tracking data on the Missouri Public Health Information Management System (MOPHIMS), an easily accessible portal for public health related data.

MO EPHT worked closely with the Missouri Department of Health and Senior Services (DHSS) Missouri Asthma Prevention and Control Program, the DHSS Childhood Lead Poisoning Prevention Program, and the Office of Epidemiology on this report.

KEY FINDINGS - In Missouri

The total economic burden of childhood asthma in 2018 attributable to the environment was $34.2 million (in 2018 U.S. dollars) (range: $11.4 million – 39.9 million)

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The total annual economic burden of childhood lead poisoning on lifetime earnings is estimated to be $61.6 million (in 2018 U.S. dollars)

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Elevated blood lead levels in tested children aged ≤ 5 years declined an average of 14.6% annually (2000-2011) and then declined 7.1% annually (2011 to 2016).

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Asthma hospitalization rates declined 2.5 percent annually among children 0 to 17 years of age (2000-2015)

Methodology

This report adopts methods established in previously published works[6,7,9] and updates these methods with current Missouri state data and information.

The Formula

The formula for estimating the economic burden of environmentally-related disease relies on the following components:

ECONOMIC BURDEN
DISEASE COUNTS X COST PER CASE X ENVIRONMENTALLY ATTRIBUTABLE FRACTION (EAF)

Economic burden is estimated as the number of cases of disease in a defined population during a specified time period, multiplied by the estimated cost per disease case, multiplied by the environmentally attributable fraction (EAF).

Counts of Disease Cases

The estimated number of children treated for asthma came from the Chronic Disease Cost Calculator (version 2.6.5058).[10,11,12]

Data on childhood asthma hospitalizations and deaths were obtained from the Missouri Department of Health and Senior Services (DHSS) data platform MOPHIMS and the on-line portal, the Missouri Information for Community Assessment (MICA).[13] The average blood lead level in Missouri children was based on the MOPHIMS EPHT data, 2000-2016.[14]

Estimating Costs per Disease Case, Direct and Indirect

For asthma, cost estimates were derived from the CDC Chronic Disease Cost Calculator for direct medical care costs per case in 2010 (inflated to 2018 U.S. dollars), including the costs of clinic visits, hospitalizations, emergency department visits, and medications.[10] Indirect costs, including wages lost from a parent who cares for a child with asthma, were also derived from the calculator, while the cost of a premature death was derived from Max et al. (2004)[15]

For childhood lead poisoning, cost estimates were calculated using wages lost from the impact of a lower IQ on lifetime earning capacity, derived from market productivity estimates in Grosse et al. (2009).[16]

The Environmentally Attributable Fraction

The EAF is the estimated proportion of disease cases that are thought to be causally associated with environmental risks. Environmental risks for this report include modifiable physical and chemical factors in homes, at work and in community environments. The calculations in this report exclude naturally occurring risks, such as radon, and behavioral risk factors such as smoking and diet, and are limited to risk factors that could be quantified based on the available scientific evidence.

Asthma Morbidity

The EAF represents the fraction of the disease that would be avoided or eliminated if the environmental risk were removed or reduced to the lowest level possible. Published relative risk estimates from the epidemiological literature and the prevalence of the exposure in the population are used to calculate the EAF. This report uses the EAF estimates first published by Landrigan et al. (2002).[7]

Childhood Asthma

About 1 in 11 Missouri children younger than 18 years of age (8.7%) currently have asthma according to the Behavioral Risk Factor Surveillance System, 2016.[17]

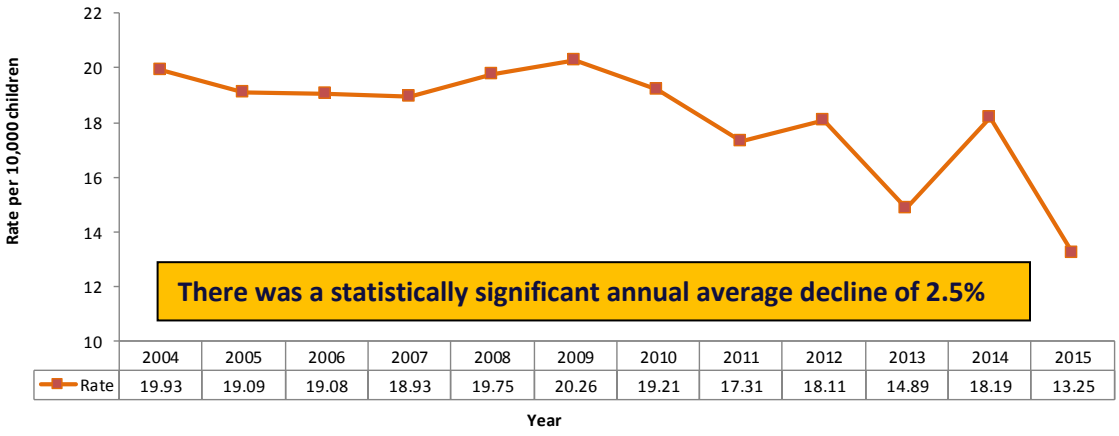
Many indicators of the burden of asthma in Missouri have been improving over time. Using the National Cancer Institute's Joinpoint software (version 4.6.0.0),[18] asthma hospitalization rates declined 2.5 percent annually among children 0 to 17 years of age in Missouri, 2004-2015 (Figure 1).

However, rates for asthma emergency department (ED) visits among children 0 to 17 years of age remained relatively stable between 2001 and 2015 (Figure 2). Statewide asthma mortality rates for all ages were unchanged between 2001 and 2016.

Disparities Observed

For 2001-2015, the asthma ED visit rate for Missouri's children 0 to 17 years of age was 9.53 per 1,000 population.[13] However, there were significant disparities in ED visit rates by race, ethnicity, and gender. The asthma ED visit rate for African-American children was more than 6 times that of whites (30.85, 95% confidence interval (CI) 30.66 – 31.04 vs. 4.99, 95% CI 4.96-5.02, respectively). Hispanic children did have a significantly lower ED visit rate than Non-Hispanic children (5.07, 95% CI 4.93-5.20 vs. 9.71, 95% CI 9.66-9.75, respectively). Boys younger than age 18 had a significantly higher ED visit rate than girls (11.30, 95% CI 11.24-11.36 vs 7.68, 95% CI 7.62-7.73, respectively).

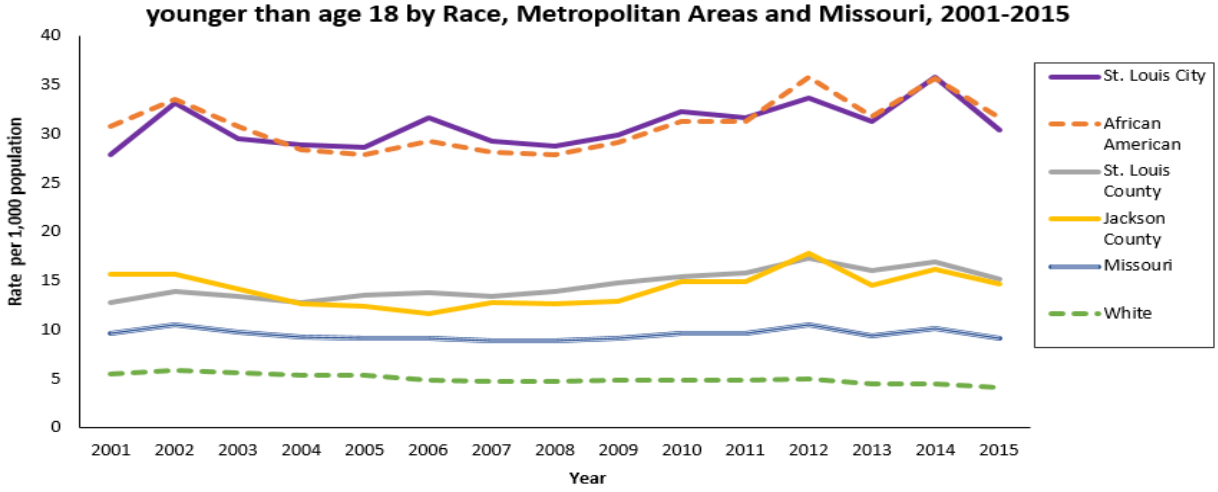
Figure 1: Rate of Asthma Hospitalizations for Missouri Children (age 0 - 17), 2004 - 2015



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rate	19.93	19.09	19.08	18.93	19.75	20.26	19.21	17.31	18.11	14.89	18.19	13.25

Source: Missouri Department of Health and Senior Services, Missouri Public Health Information Management System (MOPHIMS),, Inpatient Hospitalizations Missouri Information for Community Assessment (MICA)

Figure 2: Asthma Related Emergency Department Visit Rates Among Children younger than age 18 by Race, Metropolitan Areas and Missouri, 2001-2015



Risk Factors

Most asthma episodes (also referred to as exacerbations), including those resulting in hospitalizations, are preventable if asthma is properly managed according to established medical guidelines, which include reducing exposures to environmental triggers. A variety of factors can trigger an asthma episode, including viral respiratory infections; exposure to allergens (e.g., dust mites, dander (protein particles shed by cats and dogs), and pollen); exercise; tobacco smoke; and certain medications (e.g., aspirin and beta-blockers).

Air pollution, such as particulate matter (PM), is also associated with increased hospitalizations for asthma.[19-21]

STUDIES HAVE SHOWN

- **5-20% increases in respiratory-related hospitalizations/medical visits per 50 µg/m^3 of PM_{10} and**
- **5-15% increases per 25 µg/m^3 of $PM_{2.5}$ or $PM_{10-2.5}$ with larger estimates for asthma hospitalizations.[22]**

In the Eastern U.S., summer ozone pollution is associated with more than 50,000 hospitalizations per year for asthma and other respiratory conditions. U.S. and Canadian studies have shown warm season ozone associated increases in respiratory hospital admissions ranging from 2 – 30% per 20 parts per billion (ppb) (24 hours), 30 ppb (8 hours), or 40 ppb (1 hour).[23]

EAF for Asthma

Estimate: 30% (ranges from 10% to 35%)

A panel of experts determined 30% of asthma episodes or exacerbations can be attributable to outdoor air pollution (e.g., vehicle exhaust and power plant emissions).[7] This estimate does not include exacerbations due to other triggers such as mold, secondhand cigarette smoke, pollen, or respiratory infections.

The Cost of Asthma

The Chronic Disease Cost Calculator estimates the number of asthma cases and then calculates the direct and indirect costs per case accrued over the course of one year for children aged 0 to 17 years for 2010.[10] The inflation adjustment to 2018 U.S. dollars was calculated using the Consumer Price Index (CPI) for medical care for the Midwest region.

The number of childhood deaths in Missouri due to asthma is small and can vary from year to year. Therefore, a five-year average was used to calculate the annual average number of premature deaths. There were an average of five deaths annually due to asthma from 2012 to 2016 in Missouri.[13] The mortality cost for the premature death of a child was estimated using the present value of lifetime earnings.[15]

The following costs estimates are included in Table 1:

- Direct medical and non-medical costs
- Indirect costs, such as lost parental earnings due to school absenteeism
- Lost potential earnings due to premature death

The total cost of childhood asthma in Missouri was $114 million (in 2018 U.S. dollars), including direct medical costs, indirect cost of missed school days, and deaths due to asthma. Applying the 30% EAF to this annual cost, the total economic burden of childhood asthma in Missouri attributable to environmental risk factors was $34.2 million (in 2018 U.S. dollars) (range: $11.4 - $39.9 million).

Table 1: Annual Costs of Childhood Asthma in 2018 U.S. dollars, Missouri

Type of cost	Included in cost	Inputs (2010)	Annual value (in 2018 U.S. dollars)
Direct (medical)	Physician visits, ED, hospitalizations, prescription medication	$850 average cost x 89,300 children treated	$83,084,614
Indirect (missed school)	Lost parental earnings due to missed school days	$156 (daily wage) x 159,000 school days missed	$27,150,132
Indirect (mortality)	On average, annually there were 5 premature deaths due to asthma (2012-2016)	$700,000 per premature death x 5 deaths (average)	$3,831,054
		Estimated total cost:	**$114,065,800**
		EAF:	30%
		Environmentally attributable cost of childhood asthma:	**$34,219,740**
		Range (10%-35%):	($11,406,580 - $39,923,030)

Source: CDC Chronic Disease Cost Calculator; EAF = environmentally attributable fraction

Lead Poisoning

Lead poisoning is a medical condition that occurs when lead builds up in the body. Elevated blood lead levels (EBLLs) in young children are associated with adverse health effects, including learning impairment, attention deficits, behavioral problems, gastrointestinal problems, anemia, jaundice, blue tinge around gums, lethargy, joint and muscle pain, weight loss, encephalopathy, and even death at very high levels.

Threshold Lowered

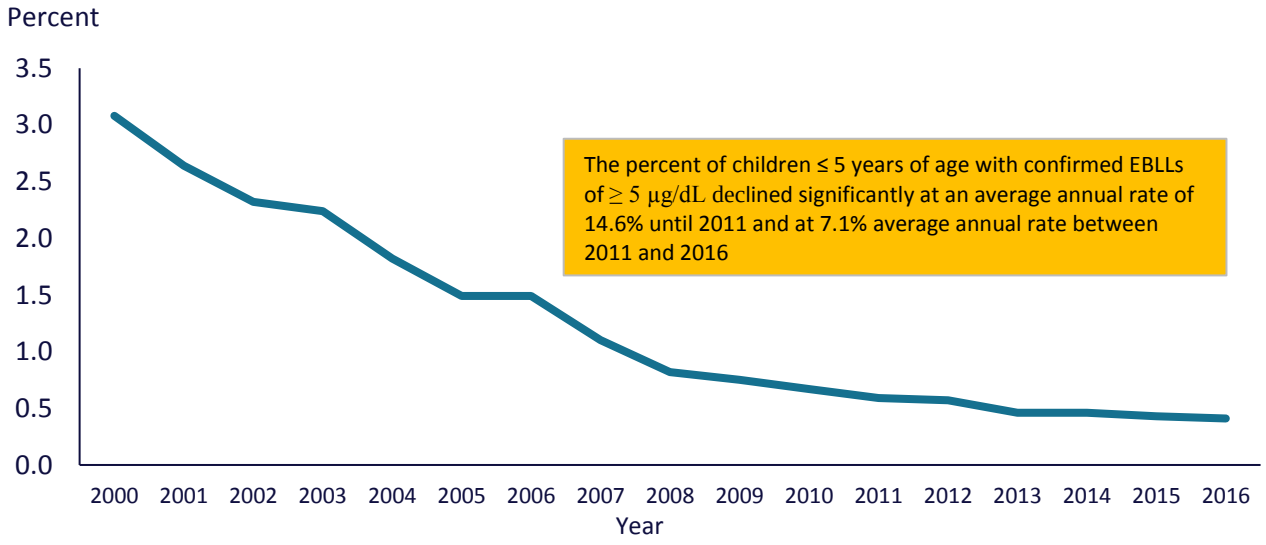
There is no safe level of exposure to lead. The threshold for an "elevated blood lead level" was recently lowered in Missouri from 10 to 5 micrograms of lead per deciliter of blood (µg/dL) based on the recent CDC reference value of 5 µg/dL and future reductions are likely.[24] This threshold is used to trigger actions for investigation and remediation of sources of lead in the home. Medical treatment is recommended when a child has an EBLL result of ≥ 45 µg/dL.

Blood Lead Levels are Declining in Missouri

Testing for lead poisoning is important as it often occurs with no identifiable symptoms. The proportion of children with lead poisoning has significantly declined over time in Missouri (Figure 3). In 2000, of those tested, there were 3.08% of children ≤ 5 years of age with EBLLs, but in 2016 it declined to 0.41%.[14] The rate of decline was 14.6 percent annually until 2011 and then from 2011 to 2016 it declined at a rate of 7.1 percent annually. The trend analysis was conducted using the National Cancer Institute's Joinpoint software version 4.6.0.0 2018.[18]

Blood lead testing in Missouri is universal in high risk areas and targeted in general risk areas, which means not every child is tested. Therefore, this measure is not generalizable and cannot be used to interpret the prevalence or incidence of all children living in Missouri.

Figure 3: Percent of Children ≤5 years of age with a Confirmed Elevated Blood Lead Level (EBLL) of ≥ 5 µg/dL, Missouri, 2000-2016



Disparities Observed

During the last 10 years (2007-2016), 0.76 percent of Missouri children under the age of 3 years had confirmed elevated blood lead levels of ≥ 5 µg/dL.

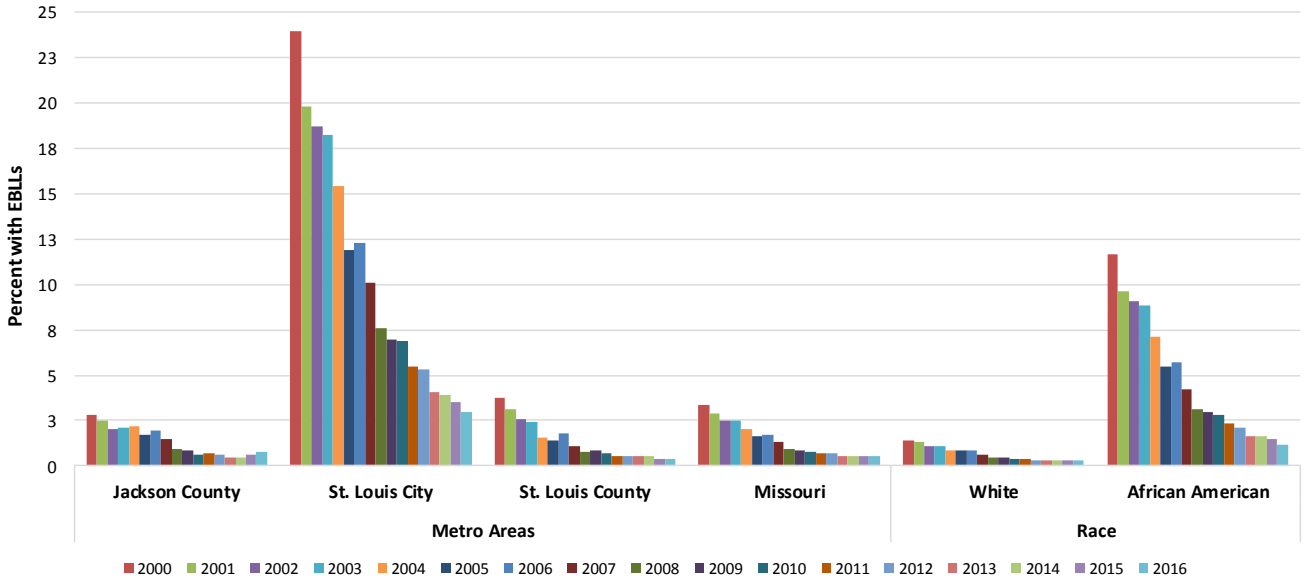
During the past couple of decades (2000-2016), the EBLLs have been declining in both whites and African-American children and in the major metropolitan areas of Missouri (Figure 4).

Of those tested, the EBLL was significantly higher among African-American than white children for the period 2006-2015 (1.59, 95% CI 1.53-1.65 vs. 0.31, 95% CI 0.30-0.32).

Risk Factors

Children younger than 6 years of age and living in homes built before 1978 are most at risk for lead poisoning. Approximately 65% of Missouri housing was built prior to 1978 and may contain some lead-based paint. Younger children are more at risk because their bodies absorb lead more easily and their brains are still developing. Lead-based paint and lead contaminated dust are common causes of lead poisoning. People can be exposed to lead by ingesting dust from deteriorated lead paint, consuming other materials contaminated with lead, or breathing aerosolized lead paint dust. Young children frequently put their hands or other objects, which may be contaminated with lead, into their mouths. The U.S. EPA estimates that more than 80% of all homes built in the U.S. before 1978 contain lead-based paint.

Figure 4: Children Age 3 years and younger with Confirmed Elevated Blood Lead Levels (EBLLs) By Metropolitan Areas, Race, and Missouri, 2000 -2016



The Cost of Lead Poisoning

EAF for Childhood Lead Poisoning

Estimate: 100% (no range)

A panel of experts determined that all cases of lead poisoning are assumed to be of environmental origin.[7] Therefore, the EAF is 100%, and no range was calculated.

Using Canfield et al. (2003) to convert blood lead levels (BLLs) into loss of IQ points, there is an estimated loss of 0.60 IQ points (ranging from 0.46 to 0.74 IQ points lost) for every 1 µg/dL increase in BLL[25]

About 1,843 Missouri children in 2016 aged 5 years and younger had a BLL ≥ 5 µg/dL. This BLL was converted into lost IQ points, then into lost lifetime earnings for boy and girls, separately.

The fraction of lifetime earnings lost due to a decline in IQ level of children with an EBLL is shown in Table 2 and Table 3.

The total annual economic burden of childhood lead poisoning on lifetime earnings in Missouri was $61.6 million in 2018 U.S. dollars.

Table 2: Calculation of Percent Lifetime Earning Lost Due to Childhood Lead Poisoning among Children aged ≤ 5 years with EBLLs ≥ 5 µg/dL, Missouri, 2016

Mean Peak BLL	IQ points lost due to lead poisoning	Total IQ points lost due lead poisoning	Lifetime earning lost due to IQ points lost	Total lifetime earnings lost
2.06 µg/dL	**0.60 IQ (0.46 – 0.74) points per 1 µg/dL**	**1.23 IQ points (0.94 – 1.52)**	**2.39% Per IQ point lost**	**2.94% (2.25-3.63)**

Table 3. Estimated Cost of Childhood Lead Poisoning Attributable to Environment among Children ≤ 5 years with EBLLs ≥ 5 µg/dL, Missouri, 2016

Lifetime earnings lost due to lead poisoning		Lifetime earnings per child (2018 U.S. dollars)	Lifetime earnings lost per child	Number of children	Lifetime earnings lost	Final economic burden (2018 U.S. dollars)
2.94%	**Boys**	**$1,407,046**	**$41,367**	**980**	**$40,539,821**	**$61,598,790**
(2.25-3.63)	**Girls**	**$830,002**	**$24,402**	**863**	**$21,058,969**	**($61.6 million)**

Strategies

Despite limitations (see page 15), this report points to the toll that asthma and lead poisoning imposes on children and their families. There are important actions that Missourians can take to reduce exposure to environmental risks and lower the economic burden of these conditions.

Actions Addressing Air Pollution

Many chronic conditions are affected by air quality. The Missouri Department of Natural Resources operates air instruments that collect data and actively monitors air data year-round. The air quality of outdoor air is determined by comparing the monitored level of air pollutants with air quality standards as established by the EPA. The National Ambient Air Quality Standards set limits for six air pollutants that affect public health:

- Carbon Monoxide
- Lead
- Nitrogen Dioxide
- Ozone
- Sulfur Dioxide
- Particulate Matter
  - PM_{10} (inhalable particulates)
  - $PM_{2.5}$ (fine inhalable particulates)

Air quality data and maps comparing asthma and relevant air quality data are available at: https://ephtn.dhss.mo.gov/EPHTN_Data_Portal/airquality/index.php In addition, pollen and mold are monitored by national allergy county stations with data available at: https://www.aaaai.org/global/nab-pollen-counts?ipb=1

Actions Addressing Childhood Asthma

Established in 2001, the Missouri Asthma Prevention and Control Program (MAPCP) links schools, communities, providers and health plans to provide and build comprehensive statewide asthma control systems through:

- School nurse training and care coordination
- Improving health care quality through guidelines-based care
- Home environment assessments and improvements

Integrating clinical care and public health yields strong partnerships and innovative interventions for improved asthma outcomes in the pediatric population. Continued improvement in systems of care and changes in policy have improved the quality of life and decreased direct and indirect economic losses attributed to asthma. MAPCP interventions are making a difference such as in Dunklin County where asthma hospitalizations among children 14 and younger fell from 160 to 21 per 10,000 children (2002-2015). Collaborations with Medicaid resulted in state plan amendments that made pediatric asthma a qualifying condition for Primary Care Health Home participation and added reimbursement for asthma education in the home and home environmental assessments. The school-based intervention, *Teaming Up for Asthma Control*, showed an annual savings of $1,431 per student following participation in the program. Analysis of school health, hospital discharge, emergency room and Medicaid claims data continue to demonstrate that positive changes are occurring statewide. The MAPCP has been funded by CDC since 2001 and its interventions have been cited in CDCs Successes of the National Asthma Control Program, 2009-2014 (www.cdc.gov/asthma/pdfs/Success_Stories_Final_508.pdf)

Actions Addressing Childhood Lead Poisoning

Established in 1993, the Childhood Lead Poisoning Prevention Program (CLPPP) assures that health care providers have current information and tools available to screen children for lead and provide primary lead poisoning prevention education. The Missouri EPHT program has created a webpage that provides a plethora of information on lead and various podcasts included in the MO Environmental Public Health Series. These podcasts include an

Overview of Lead & Health Effects, Lead Exposure Risks at Home, and Lead Exposure Risks in the Workplace. Each podcast is a brief video that showcases the prevention of a specific health condition or a public health service message and highlights important health information for the condition.

These resources are publicly available at: https://health.mo.gov/living/environment/lead/index.php, the podcasts are at https://ephtn.dhss.mo.gov/EPHTN_Data_Portal/videos.php, and blood lead level data are available at https://healthapps.dhss.mo.gov/MoPhims/EPHTHome

Missouri Environmental Public Health Tracking

Missouri Department of Health and Senior Services has been a leader in the development and implementation of the Environmental Public Health Tracking network since its inception in October 2002. The EPHT program has developed and implemented a web-based portal with both public and secure components. The portal integrates health information with environmental, hazard, risk, and demographic data and contains multiple core datasets and Nationally Consistent Data Measures (NCDMs), searchable metadata, and interactive mapping applications.

Missouri has recognized the importance of addressing the problems of identifying environmental exposures, linking those exposures to health effects, and providing timely information for public health decision-making and policy development. The purposes of the EPHT program are to drive innovation; expand, enhance, and strengthen the capabilities of both the national and EPHT network portals; and promote program linkages for data utilization. The overarching objective is to receive, translate, provide, and promote the use of public health and environmental information to improve the health of Missourians and their communities.

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Data Technical Notes

Childhood Asthma Data

The data for asthma analysis were obtained from the Chronic Disease Cost Calculator (version 2.6.5058).[10] The cost calculator was developed to provide state level estimates of medical expenditures for certain chronic diseases. Expenses included direct medical costs (physician visits, emergency department visits, hospitalizations and prescription medicine) as well as indirect costs resulting from absenteeism. Data for children in the cost calculator are only available for asthma and depression. The methods utilized by the cost calculator are described in the technical appendix for the cost calculator.[12] Briefly, data were collected from multiple sources to estimate the treated population and per-person medical and absenteeism costs. Complex survey weights were used to incorporate data from the Medicaid Statistical Information System, Current Population Survey, and Medical Expenditure Panel Survey. Regression models were used to estimate the costs associated with asthma.

The number of children, younger than 18 years of age, who died from asthma was obtained from Missouri Vital Records data available through the Death MICA.[13] Death from asthma in children is a relatively rare event in Missouri. To address the annual variation, an annual average was calculated using 5 years of data, 2012-2016.

The estimate of the economic cost of premature death in children used data from Center for Tobacco Control Research and Education, University of California, San Francisco.[15] The appendix of Max et al. (2004) contains present value of lifetime earnings by age.[15]

All costs were converted to 2018 U.S. dollars using the Consumer Price Index for Medical Services for the Midwest from the Bureau of Labor Statistics. The low and high end estimates of the EAF were applied to the costs to show a range of estimates of the economic burden.

Method for Mean Peak Blood Lead Level (BLL)

This analysis was in part based on the Fiscal Year 2015 Annual Report on Missouri Childhood Lead Poisoning Prevention Program. It includes the number of children up to age 6 during July 1, 2014 – June 30, 2015). https://health.mo.gov/living/environment/lead/links.php#maps

Results for Mean Peak BLL

The average peak BLL among Missouri children younger than age 6 years during fiscal year 2015 was 2.06 micrograms of lead per deciliter of blood (µg/ dL). About 86,472 Missouri children ≤ 5 years were tested, or 16% of all children. Missouri has universal testing in high risk areas and targeted testing in general risk areas.

***Universal Testing Areas*:**

Any child younger than age 6 living in or visiting for 10 hours per week or more in a Universal Testing or high risk area will be tested annually for lead. Childcare facilities located in Universal Testing Areas must record a "proof of lead testing" signed by the health care provider within 30 days of the child's enrollment. The statement must verify that a blood lead test was completed in the previous 12 months. If the parent/guardian does not provide proof or a written statement explaining why they do not want the child tested, the childcare facility is to offer the parent assistance in scheduling a blood lead test.

***Targeted Testing Areas*:**
From six months to six years of age, every child will be screened annually using the Healthy Children and Youth (HCY) Lead Risk Assessment Guide to determine whether the

child is at risk for lead poisoning. Responses given during the screening with the Guide may indicate the need for blood lead testing at an earlier age (six months) and/or more frequently.

Economic Cost

The measurable costs of lead exposure for this report exclude crime due to lead exposure, as well as health, earnings, and welfare use due to loss of IQ from lead exposure.[26] Landrigan et al. (2002) only includes the direct effect of lost IQ points on lifetime earnings.[7] Therefore, we calculated the economic burden of lead poisoning using only lost lifetime earnings.

Using Canfield et al. (2003) to convert BLLs into loss of IQ points, there is an estimated loss of 0.60 IQ points (ranging from 0.46 to 0.74 IQ points lost) for every 1 µg/dL increase in BLL (see Table 2, unadjusted estimate of IQ loss using the peak blood lead at 5 years of age).[25] About 1,843 Missouri children in 2016 under the age of 5 had the average peak blood lead level (BLL) of 5 micrograms of lead per deciliter of blood (µg/dL) or higher. This BLL was converted into lost IQ points, then into lost lifetime earnings for boys and girls, separately.

Table 2 computes the fraction of lifetime earnings lost due to decline in the IQ level of children with EBLLs and Table 3 computes the life time earning lost for the children with EBLLs. According to Landrigan (2002), there is a loss of 2.39% of lifetime earnings for every IQ point loss.[7] Therefore, Missouri children in 2016 have lost an average of 2.94% of lifetime earnings.

Results for Economic Cost

Market productivity data were obtained for boys and girls separately.[16] The total lifetime earnings (in market productivity) was $1,407,046 for boys and $830,002 for girls in 2016. Multiplying those amounts by 2.94% in lifetime earnings the lost equates to $41,367 lost per boy and $24,402 lost per girl. In Missouri, there were 980 boys and 863 girls in 2016 who had a confirmed elevated blood lead level of 5 µg/dL or higher, which equates to $40,539,821 lost in lifetime earnings for boys and $21,058,969 lost in lifetime earnings for girls overall. That sums to $61.6 million (in 2018 U.S. dollars).

In summary, the mean peak blood lead level in 2016 was 2.06 (µg/dL) among 1,843 Missouri children aged ≤ 5 years. Through a decrease of 1.23 IQ points due to lead exposure and a subsequent loss in lifetime earnings, resulted in a total economic burden $61.6 million (in 2018 U.S. dollars).

Limitations of this Analysis

This report addresses specific costs that are measurable with the available data and focuses on environmental risks that are amendable to change. Several costs are not included in the estimates. For example, the costs to treat childhood lead poisoning or conduct environmental assessments of lead exposure are not included, either because the cost is smaller than the cost of the lost lifetime earnings or because the cost cannot be estimated. This report does not capture the long-term effects of environmental exposures that occur at a young age, but do not appear as disease until later in life. Therefore, the costs calculated in this report likely underestimate the true cost to Missouri's economy of asthma episodes and lead poisoning in children that are attributable to environmental risk factors.

Environmentally Attributable Fraction (EAF)

The EAFs for asthma used in this report are based on published scientific studies that measure the relationship between specific risks and disease in populations. However, estimating the EAF is itself not a scientific measurement, but is based on judgment by experts. The studies used to estimate the EAFs are not specific to Missouri populations, and the estimates do not include the most recent science published in the past few years. However,

this report does provide a comparison to previously published reports using the reference values. The true fraction of these diseases that is attributable to environmental factors in Missouri is unknown. The EAF can change over time in a given population, and it can be different from one population to the next. The EAF can also be modified over time by better population health care that leads to reduced population vulnerability, and environmental interventions that reduce exposure.

We know that the burden and cost of environmentally attributed disease in Missouri's children is not shared equally across all communities in the state. Ample evidence points to significant disparities in our state with respect to the occurrence of childhood asthma episodes, and the prevalence of blood lead poisoning, both of which are known to be greater in lower income communities. In addition, environmental exposures to pollutants are not shared equally. For example, residential communities located close in proximity to high traffic corridors experience greater pollutant levels from vehicle exhaust. Communities that are economically disadvantaged are less able to take actions to avoid environmental risks in their homes and neighborhoods, which further leads to a disparate burden. Nevertheless, the DHSS programs will continue to protect health, keep people safe, and strive for health equality for every resident of the state.

MO EPHT worked closely with the Missouri Department of Health and Senior Services (DHSS) Missouri Asthma Prevention and Control Program, Childhood Lead Poisoning Prevention Program, and the Office of Epidemiology on this report.

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