Calculating Societal Benefits of Reducing Lead Exposure

2025 National Lead and Healthy Housing Conference

August 5, 2025 in Kansas City, Missouri

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Unleaded Kids – **www.unleadedkids.org**

Agenda

- Why monetize societal benefits?
- Health effects of low-level lead exposure
- Studies monetizing societal benefits
- Why IQ, CVD, ADHD, and low birthweight?
- EPA's All Ages Lead Model (AALM)
- Putting it into practice
- Next steps

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Why monetize societal benefits?

Causal health effects of low-level lead exposure

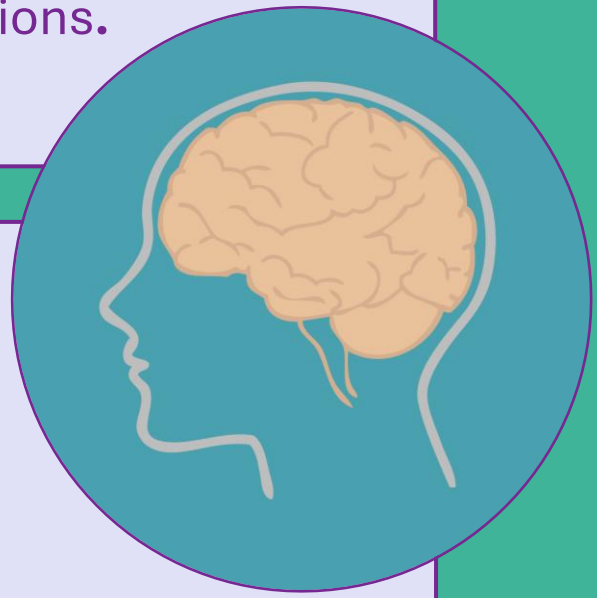
CHILDREN

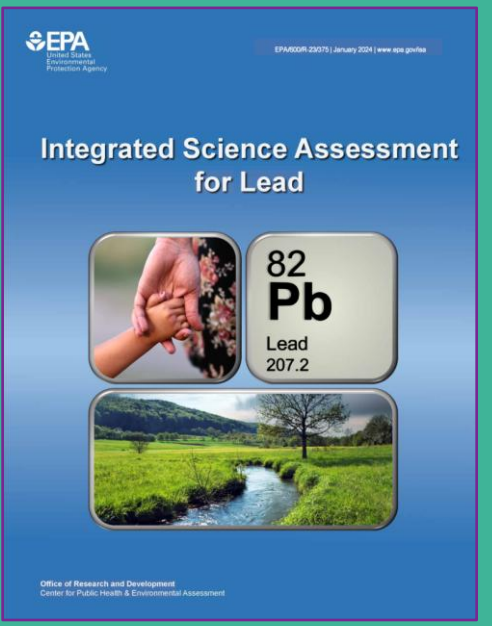
Cognitive effects: Recent epidemiologic studies add to the evidence of harm below 5 microgram per deciliter (µg/dL) blood lead levels (BLLs). Recent animal studies support the finding.

Attention, impulsivity, and hyperactivity behaviors: Recent studies of children with mean BLLs at or below 5 µg/dL support and extend 2013 conclusions.

ADULTS

Cognitive effects: Recent epidemiologic studies provide additional evidence of association with cumulative and early childhood exposure.





January 2024

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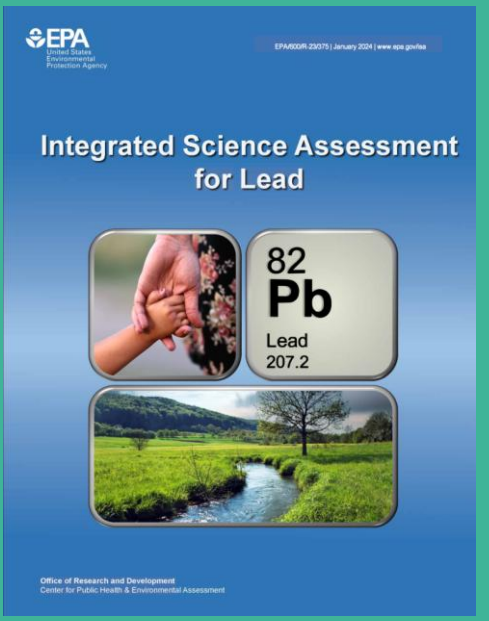
Causal health effects – beyond the brain

- Harmful health effects of lead found to be **causal (cont.)**
  - **Cardiovascular effects and cardiovascular-related mortality:** Strongest new evidence comes from studies demonstrating that lead increases blood pressure. There is substantially more evidence of cardiovascular-related death and changes in physiology.
  - **Renal effects:** Recent studies support and extend 2013 conclusions particularly for mean BLLs at or below 5 µg/dL.
  - **Development effects:** Recent studies show delays in onset of puberty in both boys and girls, particularly at lower BLLs.
  - **Male reproductive function effects:** Recent epidemiologic studies show consistent association with decreased sperm/semen production and quality.
  - **Total nonaccidental mortality:** Recent epidemiologic studies build on evidence including at mean BLLs less than 2.5 µg/dL.



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Studies monetizing societal benefits

Levin & Schwartz (2023)

- 16 health endpoints EPA determined are causally related to lead exposure
- 1 health endpoint that EPA has used elsewhere: preterm birth
- See https://pubmed.ncbi.nlm.nih.gov/37080271/

USAID (2024)

- Claims a staggering 1.6 million lives each year
- Accounts for upwards of one fifth of the educational gap between rich and poor countries
- Creates at least a $1 trillion drag on the global economy

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Why IQ, CVD, ADHD, and low birthweight?

- EPA completed rigorous review process for these four harms:
  - Reviewed all available studies that could be used to develop quantitative relationships between changes in lead exposure and/or changes in blood lead levels and changes in key health endpoints.
  - Evaluated the studies for quality and potential biases.
  - Developed a separate report for each health endpoint. In addition to the quality review findings, each report provides quantitative estimates, based on the identified functions, of potential changes in the health endpoint.
  - Had the reports for quantified health endpoints reviewed by EPA experts and external peers.
  - Successfully completed inter-agency review of the approaches through White House's Office of Management and Budget.

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IQ: Calculating increased lifetime earnings

- https://unleadedkids.org/special-series-iq/2025/03/04/
- EPA first used in 1998 for proposed lead-hazard standards

Type of Effect	Description	Estimate ('95 USD)
Effect of a 1-point reduction in IQ	2.379% of avg lifetime earning lost	$9,360
Cost of additional education	Direct costs ($316) & opportunity costs ($627) of additional education	$1,014
Total effect of 1-Point Reduction in IQ	Additional education from the effects on earnings lost	$8,346
Special Education (IQ < 70 points)	Cost of special education beginning at age 7 and ending at age 18	$53,836
Compensatory Education (Blood lead > 20 mcg/dL)	Cost of compensatory education beginning at age 7 and ending at age 9	$15,298
Medical Intervention (for several blood lead ranges)	Cost of blood lead screening and medical intervention for children less than 6 years old	$58 to $9,843

IQ: Calculating increased lifetime earnings

- Values in 2024
- As an example of the new formula, a 10% reduction in a blood lead level:
  - Increase the average per child's IQ from 0.14 to 0.36 points resulting in increased lifetime earnings from $5,900 to $15,100
  - If increase typical for all 3.6 million children born in a year, the societal benefit would be $21 billion to $54 billion/year
- Estimated IQ-related societal benefits for EPA's:
  - Lead and Copper Rule Improvements were $6.8 billion to $11 billion/year
  - Dust Lead Standard and $831 million to $3.1 billion/year

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IQ: Calculating increased lifetime earnings

- Based on EPA Economic Analysis for Lead and Copper Rule at § 5.5.1

Exhibit 5-25 Updated Estimates for Lifetime Earnings, Additional Education Costs, and Lost Earnings from Additional Education (2022 USD), discounted at 2 percent to age 7

Estimate	Updated Salkever Estimates		
	Male	Female	Male and Female Combined
1. Lifetime Earnings	$2,174,849	$1,424,497	-
2. IQ Effect	1.87%	3.41%	-
3. IQ Effect*Lifetime Earnings	$40,700	$48,559	$44,551
4. Additional Education Costs	$1,702	$1,940	$1,819
5. Lost Earnings (from additional education)	$594	$415	$506
6. Value of an IQ Point (3 - (4+5))	**$38,404**	**$46,204**	**$42,226**

Note: The EPA uses of the term "2 percent discount rate" with regard to the calculation of the IQ point high and low estimates is shorthand for a declining discount rate which begins with a 2 percent discount rate for the years 2024-2079, a 1.9 percent discount rate used for the years 2080-2096, and a 1.8 percent discount rate used in years 2095-2102. This declining rate structure was implemented to comply with updates to OMB Circular A-4 guidance.

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IQ: Calculating increased lifetime earnings

High benefits calculation based on Lanphear et al. 2019

$$IQ\ Loss = \beta \times \ln\left(\frac{PbB_1}{PbB_2}\right) \qquad \text{(Equation 9)}$$

Where:

β = Corrected lifetime beta estimate from Lanphear et al. (-3.25)

PbB_1 = Pre-rule BLL

PbB_2 = Post-rule BLL

Low benefits calculation based on Lanphear et al. 2019

$$IQ\ Loss = \beta \times \ln\left(\frac{PbB_1 + 1}{PbB_2 + 1}\right) \qquad \text{(Equation 10)}$$

Where:

β = Lifetime beta estimate from Crump et al. (2013) independent analysis (-3.25)

PbB_1 = Pre-rule BLL

PbB_2 = Post-rule BLL

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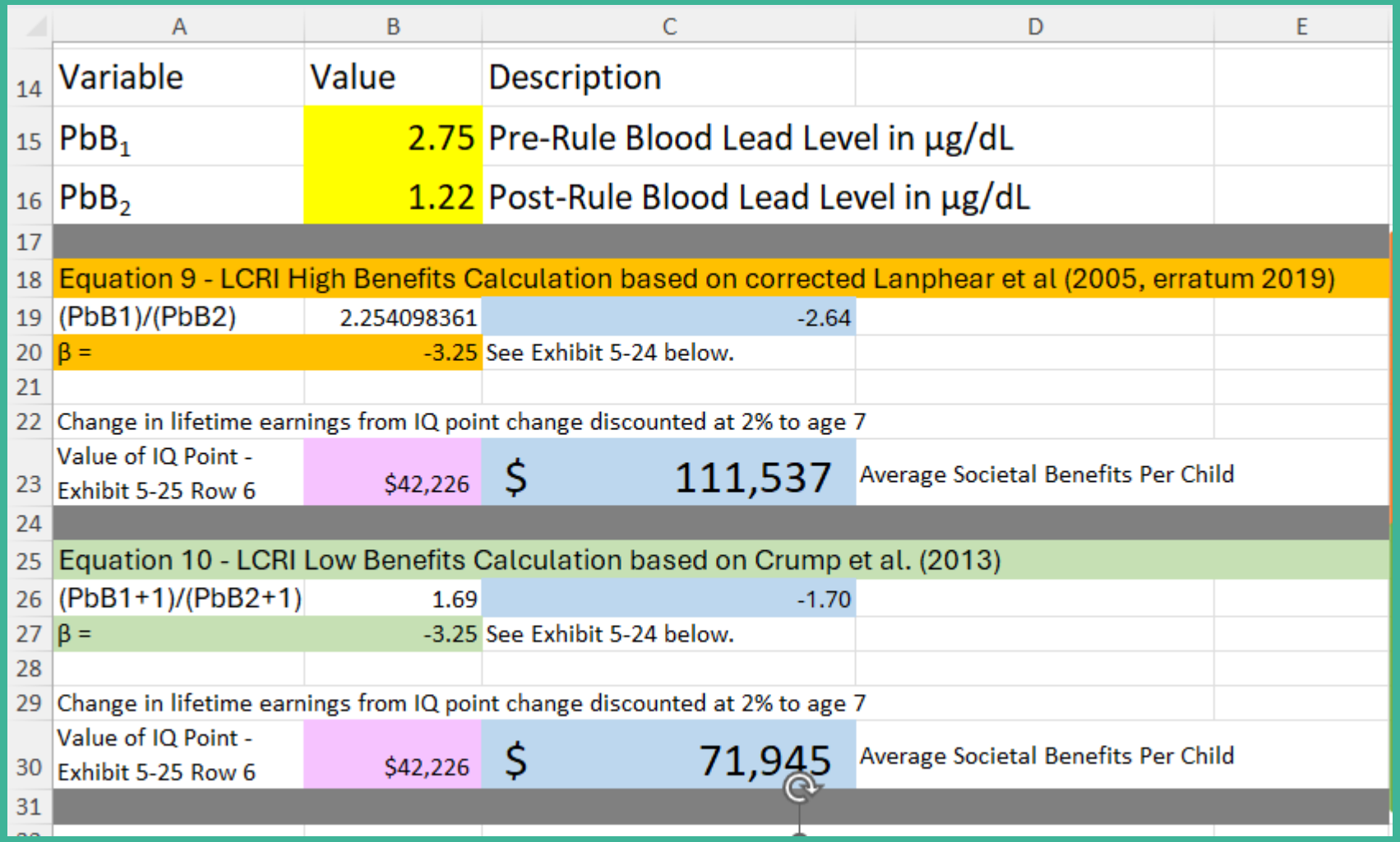
IQ: Calculating increased lifetime earnings

- Download spreadsheet



	A	B	C	D	E
14	Variable	Value	Description		
15	PbB_1	2.75	Pre-Rule Blood Lead Level in µg/dL		
16	PbB_2	1.22	Post-Rule Blood Lead Level in µg/dL		
17					
18	Equation 9 - LCRI High Benefits Calculation based on corrected Lanphear et al (2005, erratum 2019)				
19	(PbB1)/(PbB2)	2.254098361	-2.64		
20	β =	-3.25	See Exhibit 5-24 below.		
21					
22	Change in lifetime earnings from IQ point change discounted at 2% to age 7				
23	Value of IQ Point - Exhibit 5-25 Row 6	$42,226	$ 111,537	Average Societal Benefits Per Child	
24					
25	Equation 10 - LCRI Low Benefits Calculation based on Crump et al. (2013)				
26	(PbB1+1)/(PbB2+1)	1.69	-1.70		
27	β =	-3.25	See Exhibit 5-24 below.		
28					
29	Change in lifetime earnings from IQ point change discounted at 2% to age 7				
30	Value of IQ Point - Exhibit 5-25 Row 6	$42,226	$ 71,945	Average Societal Benefits Per Child	
31					

CVD: Calculating value of fewer premature deaths

- First used in 2024 rules on dust-lead and lead in drinking water
- As an example, a 10% reduction in the adult median blood lead level would reduce:
  - Cardiovascular disease (CVD)-related premature deaths between 6,213 and 16,344 nationally for societal benefits of $80 billion to $212 billion/year
- For context, the estimated CVD-related societal benefits for EPA's
  - Lead and Copper Rule Improvements were $9.5 billion to $25 billion/year
  - Dust Lead Standard were $614 million to $6.9 billion/year.

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CVD: Calculating value of fewer premature deaths

- CDC's Lead Exposure and Prevention Advisory Committee (LEPAC) adopted a Protecting Lead Exposure in Adults **Draft Report** that found that
  - Lead exposure is a cardiovascular risk factor **on par with high cholesterol, smoking, and high blood pressure**
  - **R**isk "has received relatively sparse attention in health professional education and outreach to the lay public."
- Value of Statistical Life (VSL) is an estimate of the public's willingness to pay for small reductions in mortality risks.
  - Based on the aggregate dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year.
- ***Use only for BLLs < 5 mcg/dL***

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CVD: Calculating value of fewer premature deaths

Based on EPA Economic Analysis for Lead and Copper Rule at § § 5.5.7 and 5.5.8

Exhibit 22. Age- and Sex-Specific Cardiovascular Disease Mortality Rates in the United States in 2014, Based on CDC's WONDER Database

Age (years)	Sex	Number of Deaths	Total Population	CVD Mortality Rate, Y_1
40-49	M	16,164	20,566,856	7.86E-04
	F	7,886	20,912,669	3.77E-04
50-59	M	47,045	21,521,569	2.19E-03
	F	21,930	22,560,689	9.72E-04
60-69	M	74,155	16,127,000	4.60E-03
	F	39,275	17,764,398	2.21E-03
70-80	M	98,852	9,151,537	1.08E-02
	F	74,989	11,107,883	6.75E-03
Total (40-80 years)	**M**	**236,216**	**67,366,962**	**3.51E-03**
	F	**144,080**	**72,345,639**	**1.99E-03**
	Both	**380,296**	**139,712,601**	**2.72E-03**

Source: CDC - National Center for Health Statistics (2014)

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CVD: Calculating value of fewer premature deaths

Download spreadsheet

7	**Instructions:**		
8	1. Use EPA's All Ages Lead Model to Estimate Pre-Rule and Post-Rule Blood Lead Levels for Typical Child		
9	2. Enter Pre-Rule and Post-Lead Blood Lead Levels in Yellow Highlighted Cell		
10	3. Enter Population Expected to Benefit from Change in Blood Lead Level in Yellow Highlighed Cell		
11	4. Use the Central Estimate for Both Aoki et al 2016 and Lanphear et al. 2018 from Blue Highlighted Box		
12	5. See Low-End and High-End Estimated Changes in Lifetime Earnings in Blue Highlighted Box.		
13			
14	Variable	Value	CVD Mortality Risk Reduction
15	x_1 =	1.17	Baseline blood lead level
16	x_2 =	1.053	Post-rule blood lead level
17	pop	139,712,601	Population for whom the change in blood lead occurs.
18	y_1	0.00272	Baseline hazard rate of CVD premature mortality for 40-80 year olds in baseline scenario (i.e., without the rule)
19	β =	See below for each	Beta coefficient, which represents the change in CVD mortality risk per unit change in blood lead
20	Logz =	10	Log transformation to the base z (e.g., log10)

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CVD: Calculating value of fewer premature deaths

High benefits calculation based on Lanphear et al. 2018

31	Lanphear et al. 2018 (High Benefit Estimates) (blood lead levels < 5 µg/dL					
32	Central β	0.96	Central beta estimate			
33	Lower β	0.54	Lower beta estimate (based on lower bound of 95% confidence interval for hazard ratio)			
34	Upper β	1.37	Upper beta estimate (based on upper bound of 95% confidence interval for hazard ratio)			
35						
36			CVD Mortality Risk Reduction	CVD Deaths Avoided	CVD Deaths Avoided	
37		Central	0.00011690	16,332	$	211,986,817,320
38		Lower	0.00006639	9,275	$	120,387,301,577
39		Upper	0.00016528	23,091	$	299,723,347,714

Low benefits calculation based on Aoki et al. 2016

22	Aoki et al. 2016 (Low Benefit Estimates)					
23	Central β	0.36	Central beta estimate			
24	Lower β	0.05	Lower beta estimate (based on lower bound of 95% confidence interval for hazard ratio)			
25	Upper β	0.68	Upper beta estimate (based on upper bound of 95% confidence interval for hazard ratio)			
26			CVD Mortality Risk Reduction	CVD Deaths Avoided	Value	
27		Central	0.00004444	6,209	$	80,588,260,862
28		Lower	0.00000622	868	$	11,272,355,235
29		Upper	0.00008333	11,642	$	151,116,277,971

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ADHD: Preventing cases in children (and adults)

- First used in 2024 rules on dust-lead and lead in drinking water
- As an example, a 10% reduction in the median blood lead level of children aged 6 to 11 years would reduce diagnosed attention deficit hyperactive disorder (ADHD) cases
  - Between 7,410 and 18,809/year nationally for societal benefits of $953 million to $3.46 billion per year.
- For context, the estimated ADHD-related societal benefits for EPA's:
  - Lead and Copper Rule Improvements were $196 million to $600 million/year
  - Dust Lead Standard were $129 million to $274 million/year.

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ADHD: Preventing cases in children (and adults)

Based on EPA Economic Analysis for Lead and Copper Rule at § § 5.5.3 and 5.5.4

Exhibit 5-26: Present Value of Avoided ADHD Cases 2022 USD, Per Case

Assumed Persistence of ADHD Into Adulthood	Age at ADHD Diagnosis	2% Discount Rate
90%	11 (High- Froelich)	$184,149
29.3%	7 (Low- Ji)	$128,559

Note: The EPA uses of the term "2 percent discount rate" with regard to the calculation of the ADHD high and low estimates is shorthand for a declining discount rate which begins with a 2 percent discount rate for the years 2024-2079, a 1.9 percent discount rate used for the years 2080-2085. This declining rate structure was implemented to comply with updates to OMB Circular A-4 guidance.

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ADHD: Preventing cases in children (and adults)

Download spreadsheet

7	**Instructions:**		
8	1. Use EPA's All Ages Lead Model to Estimate Pre-Rule and Post-Rule Blood Lead Levels for 6 to 11 Year Old Child		
9	2. Enter Pre-Rule and Post-Lead Blood Lead Levels in Yellow Highlighted Cell		
10	3. Enter Population Expected to Benefit from Change in Blood Lead Level in Yellow Highlighed Cell		
11	4. See Low-End and High-End Estimated Changes in Lifetime Earnings in Blue Highlighted Box.		
12			
13			
14	**5.5.3 Concentration-Response Function for Lead and ADHD**		
15	Variable	Value	
16	$Blood\ Pb_i$	0.475	Initial blood leal (µg/dL)
17	$Blood\ Pb_f$	0.4275	Final blood leal (µg/dL)
18	Population	3,600,000	Number of children in the population of interest
19	$\ln(Blood\ Pb_i)$	-0.744	
20	$\ln(Blood\ Pb_f)$	-0.850	
21	X	0.105	$\ln(Blood\ Pb_i)-\ln(Blood\ Pb_f)$
22	p_0	0.096	Baseline rate of AHDH in the population of interest (assumed to be 9.6% based on Danielson et al (2018).

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ADHD: Preventing cases in children (and adults)

High benefits calculation based on Froelich et al. 2009

36	Equation 11 using Froelich et al. (2009) - High-End Risk and High-End Value						
37	$\beta 1$		0.558	Beta estimate from study: 0.223 using Ji et al. (2018) or 0.588 using Froelich et al. (2009)			
38	$e^{-\beta(x)}$		0.943				
39	Y		0.948	$(1-p_0)*e^{-\beta(x)}+p_0$			
40	z		0.101	$p_0/((1-p_0)*e^{-\beta(x)}+p_0)$			
41	y		-0.005	Estimate for one child		(18,809.00)	
42	ΔADHD		(18,809)	Change in number of children with ADHD among population of interest with change in blood lead level			
43	Benefits of Avoided ADHD	$	184,149	Present value of avoided ADHD cases in 2022 USD at 2% discount rate)			
44	Age at AHDH Diagnosis		11				
45	Societal Benefits	$	3,463,659,457	Per year			

Low benefits calculation based on Ji et al. 2018

24	Equation 11 using Ji et al. (2018) - Low-End Risk and Low-End Value						
25	β_1		0.223	Beta estimate from study: 0.223 using Ji et al. (2018) or 0.588 using Froelich et al. (2009)			
26	$e^{-\beta(x)}$		0.977				
27	Y		0.979	$(1-p_0)*e^{-\beta(x)}+p_0$			
28	z		0.098	$p_0/((1-p_0)*e^{-\beta(x)}+p_0)$			
29	y		-0.002	Estimate for one child		(7,410.49)	
30	ΔADHD		(7,410)	Change in number of children with ADHD among population of interest with change in blood lead level			
31	Benefits of Avoided ADHD	$	128,559	Present value of avoided ADHD cases in 2022 USD at 2% discount rate)			
32	Age at AHDH Diagnosis		7				
33	Societal Benefits	$	952,684,950	Per year			

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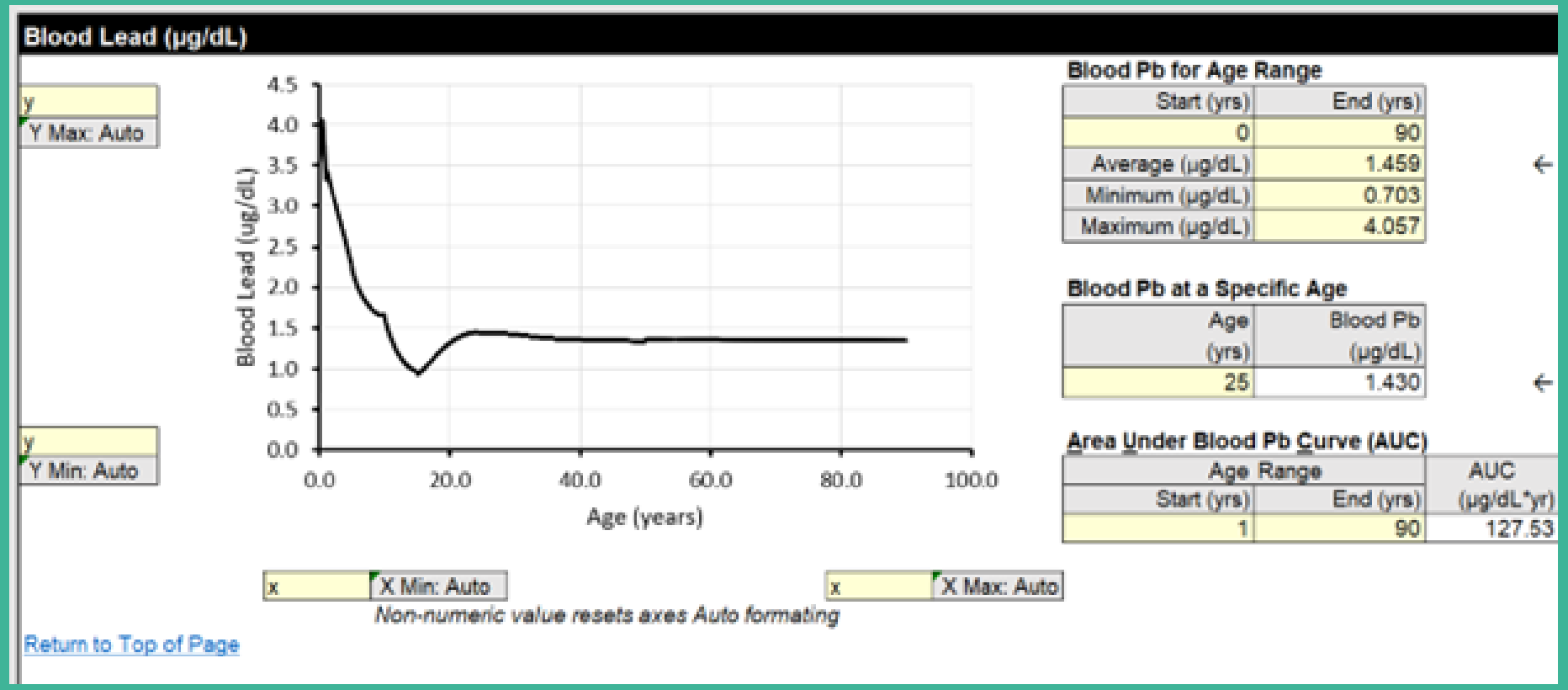
Preventing low birthweight babies

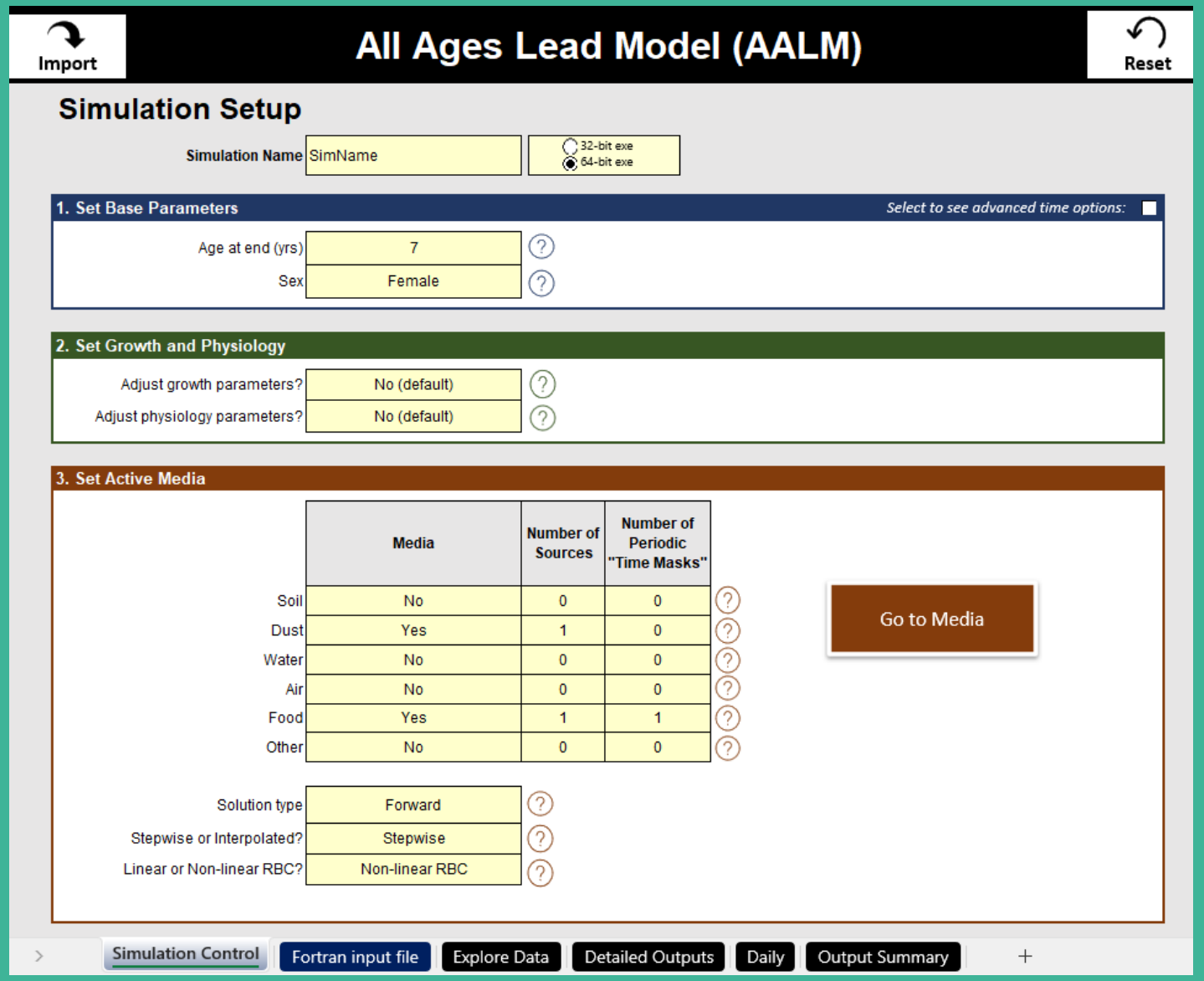
- First used in 2024 rules on dust-lead and lead in drinking water
- For context, the estimated ADHD-related societal benefits for EPA's:
  - Lead and Copper Rule Improvements were $3.9 to $4,4 million/year
  - Dust Lead Standard could not be monetized using cost-of-illness approach

EPA's All Ages Lead Model

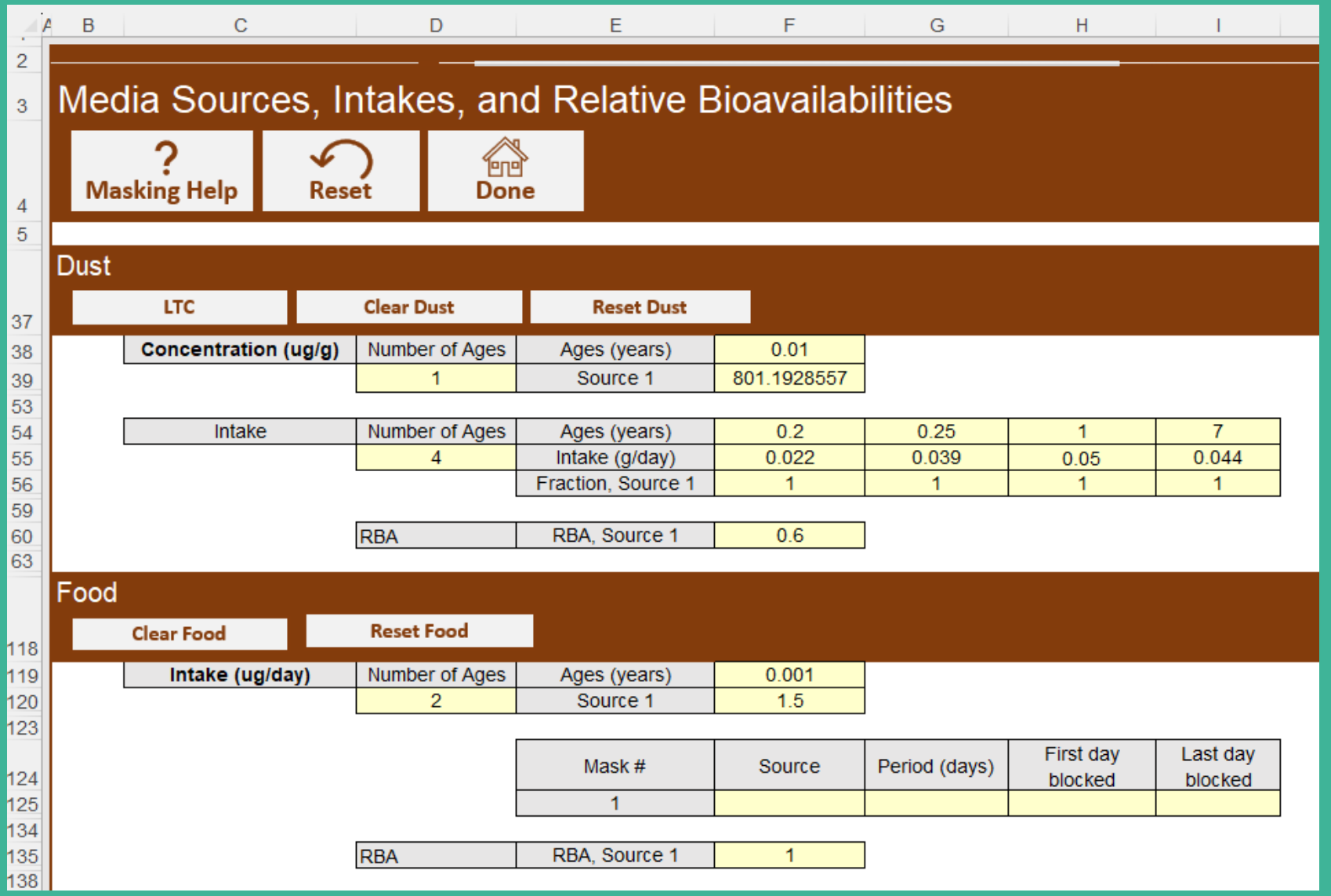
- Version 3 released by EPA in 2024 at https://www.epa.gov/land-research/all-ages-lead-model-aalm



EPA's All Ages Lead Model



EPA's All Ages Lead Model



Media Sources, Intakes, and Relative Bioavailabilities

Masking Help | Reset | Done

Dust

LTC | Clear Dust | Reset Dust

Concentration (ug/g)	Number of Ages	Ages (years)	0.01
	1	Source 1	801.1928557

Intake	Number of Ages	Ages (years)	0.2	0.25	1	7
	4	Intake (g/day)	0.022	0.039	0.05	0.044
		Fraction, Source 1	1	1	1	1

RBA	RBA, Source 1	0.6

Food

Clear Food | Reset Food

Intake (ug/day)	Number of Ages	Ages (years)	0.001
	2	Source 1	1.5

Mask #	Source	Period (days)	First day blocked	Last day blocked
1				

RBA	RBA, Source 1	1

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Putting it into Practice

Calculating Societal Benefits of Reducing Lead Exposure

2025 National Lead and Healthy Housing Conference

August 5, 2025 in Kansas City, Missouri

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