Green & Healthy Homes Initiative®

Return-on-Investment Calculator for Lead Poisoning Prevention

Advancing the economic case for financing preventive interventions

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Contents

Background

In the United States, an estimated 535,000 children aged 1-5 years have blood lead levels higher than 5 µg/dL,[1] which is the Centers for Disease Control and Prevention's (CDC) defined action level. Decades of research has established that there is no safe level of lead in the human body, and even the smallest amount of lead in a child will lead to deficits in brain development and health. Long-term effects include poor health outcomes, cardiovascular disease,[2] behavioral issues such as Attention Deficit Hyperactivity Disorder (ADHD), lower lifetime earnings, need for special education, and increased potential of criminal activity.[3]

The dangers of lead poisoning are well understood but preventing lead exposure is drastically underfunded nationally. While the majority of lead prevention funding comes from federal agencies such as the Department of Housing and Urban Development (HUD) and the CDC, lead poisoning prevention touches many other agencies and could benefit from a broader base of funding. For example,

- **Department of Education:** costs incurred for special education and lost classroom productivity that results from behavioral issues,
- **Centers for Medicare & Medicaid Services (CMS)**: short-term and long-term costs that result from health complications due to lead poisoning,
- **Department of Justice (DOJ)**: direct and indirect costs that result from lead poisoning that are associated with crime and the justice system, and
- **Treasury**: lost tax revenue that results from lower IQ and earning potential of lead poisoned individuals.

The economic impact of lead poisoning is felt by cities, counties and states as well. A study of the impact of the reduction in lead poisoning in Maryland spearheaded by GHHI working in partnership with local and state policy makers was estimated to be $63.8 billion in avoided losses of lifetime earnings, from 1994 to 2015.[4]

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[1] µg/dL, or micrograms per deciliter, is a measure of lead concentrated in a person's bloodstream.
[2] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NCEE&dirEntryID=342855
[3] Gould, E. (2009). Childhood lead poisoning: conservative estimates of the social and economic benefits of lead hazard control. Environmental health perspectives, 117(7), 1162-1167.
[4] Analysis by Duke University Environmental Law and Policy Clinic. PowerPoint presentation, December 2017.

Purpose of Calculator

A dollar invested in lead paint hazard control returns $17 to $221 to society.[5] Despite the power of this staggering and often-cited statistic, the collective benefits of lead poisoning prevention are dispersed across many different sectors and accrue over the lifetime of a lead poisoned individual. This makes it difficult to translate the total societal benefit of prevention into a straightforward case for financing by a single payer or group of payers. It has also hindered investment in lead poisoning prevention from meeting the scale of the problem.

The purpose of the Lead Financing Calculator is not only to compute the value of prevention across sectors, but also to allow users to control key inputs of calculations to suit the conditions of their unique situations. Examples of inputs include:

- **Timeframe:** the value of prevention accrues over an individual's lifetime, but a payer may have a shorter time horizon for considering costs and benefits of a lead intervention.
- **Attribution of benefits:** selecting specific outcomes measures across sectors—Healthcare, Education, Criminal Justice, and Economic—to see how the value of prevention is distributed, to advance a cost-sharing framework for financing. For example, the user may only want to select those sectors in which partners are in current discussions or can feasibly participate in a project.
- **Scale of intervention:** targeting prevention for 200 versus 2,000 homes per year, for example, significantly alters intervention costs and total value of prevention.
- **Transaction costs:** when considering different funding mechanisms, it may be important to consider things such as evaluation costs and project management costs.

We hope that policymakers, advocates, and practitioners use the Lead Financing Calculator to advance conversations about prevention and develop tangible financing arrangements that scale lead poisoning prevention programs in their jurisdictions.

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[5] Ibid.

Calculator Inputs

The calculator is largely based on the publication *Childhood Lead Poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control* by Elise Gould,[6] with monetary costs updated to 2020 US dollars. Calculations are based on the costs and benefits of lead paint hazard control and lead service line replacement, as opposed to other remediation costs associated with soil, air, food, or consumer products. Where applicable and as described below, we use alternate calculation methods and data from other sources to complement the Gould baseline data.

Program Design & Operations

The calculator assumes a primary prevention strategy where the intervention targets homes for enrollment, as opposed to identifying buildings to remediate after a resident child has been lead poisoned. As an example, a project could develop an algorithm for targeting homes based on neighborhood, year of construction, and historical inspection records. Cost and benefit calculations are based on a cohort model, which is meant to reflect how program enrollment would operate year to year. Enrollment in and attrition out of the program occur on an annual basis, where the user controls the number of cohorts to enter the program and the number of homes enrolled per cohort.

Program Design: Calculator Inputs

- **Number of cohorts:** Years in which the program enrolls a new set of homes for intervention. For example, 'five cohorts' means that the program enrolls new homes into the program for five consecutive years.
- **Number of homes per cohort:** For each cohort, this is the number of homes enrolled in the program.
- **Years of cost-savings:** Number of years that cost-savings and value of benefits are counted. Setting this to 30, for example, means that the calculator sums the value of prevention only through year 30 (i.e. earning potential in year 31 and beyond is not counted).
- **Years of evaluation cost:** If evaluation costs are part of the program, this input indicates the number of years that evaluation costs are incurred. Annual evaluation cost is included in the Program Cost section.
- **Years of project management cost:** If project management costs are part of the program, this input indicates the number of years that project management costs are incurred. Annual project management cost is included in the Program Cost section.

[6] Ibid.

Program Operations: Calculator Inputs

- **Annual attrition:** Annual percentage of children who leave the program (i.e. whose future benefits from the intervention will not be counted). For example, this rate includes individuals who might move out of the jurisdiction where the program operates or move to a new home that is not lead-safe.
- **Number of children per home:** Because enrollment assumptions are based on homes enrolled per year, the user can adjust the expected number of children per home. This acts as a multiplier for benefits that accrue to the project.
- **Annual probability of future EBLL (elevated blood level) in targeted home:** Because primary prevention targets the home rather than the child, there is an inherent probability that the remediated home will prevent a child from being exposed to lead (and conversely, probability that a remediated home does not prevent lead exposure-perhaps because a child never lives there or is poisoned despite remediation).
- **Federal income tax rate:** Used to calculate marginal federal income tax revenue from increased individual earnings.[7]
- **State and local income tax rate:** Used to calculate marginal state and local income tax revenue from increased individual earnings.

Value from Prevention

The calculator computes the value of prevention across a range of sectors and categories: short-term medical, long-term medical, cardiovascular disease mortality, ADHD, special education, crime, earning potential, tax revenue, and energy savings. In this section of the calculator, the user selects which values to include in the overall cost-benefit analysis. We allow the user to select these options because we understand that payer(s) in some circumstances may not be willing or able to pay for all outcomes that result from prevention; by selecting which categories to include, the user can customize the analysis to fit their specific financing arrangement. For each of the benefits listed below, we apply an 85% rate of prevention to account for lead exposure that may occur from paint- and water-based hazards; this is based on estimates that paint contributes to 70% of lead poisoning cases and water 15%.[8] The remaining 15% of cases may be attributable to sources like soil, consumer products, food, etc. that would not be mitigated by the intervention.

Medical Benefits, Short-Term

Our analysis uses healthcare savings estimates presented by Gould and adjusts those values to 2020 dollars for children zero to six years old. Savings are derived from reduction in medical

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[7] Average tax rates for 2020: https://taxfoundation.org/us-tax-burden-on-labor-2020

[8] Levin, R., Brown, M. J., Kashtock, M. E., Jacobs, D. E., Whelan, E. A., Rodman, J., ... & Sinks, T. (2008). Lead exposures in US children, 2008: implications for prevention. Environmental Health Perspectives, 116(10), 1285-1293.

treatments that would be provided to a lead poisoned child: venipuncture, capillary blood sampling, lead assay, risk assessment questionnaire, nurse-only visit, physician visit, environmental investigation ad hazard removal, oral chelation, and intravenous chelation. Note that Gould's analysis is based on healthcare costs for children with a blood lead level starting at 10 μg/dL. The Lead Financing Calculator uses a reference level of 5 μg/dL and assumes the same healthcare costs for all individuals at and above the updated threshold.

Medical Benefits, Long-Term

Gould discusses but does not include calculations for long-term healthcare costs that result from lead poisoning such as neurologic disorders, adult hypertension, stroke, kidney malfunction, elevated blood pressure, and osteoporosis.[9] We attempt to capture some aspect of this by estimating an increase in lifetime healthcare costs for lead poisoned individuals at a 5% marginal cost above the average cost of care for a Medicaid member. This amounts to a little over half of the total savings calculated solely from cardiovascular disease costs[10] and attribution to blood lead;[11] the estimate does not account for potential economic benefits derived from improved outcomes from the additional health areas listed above. We take this conservative approach because while there is evidence that infers and suggests causal relationship between some health outcomes like cardiovascular disease,[12] quantifying these outcomes varies widely and in some cases is currently being debated[13].

Cardiovascular Disease (CVD) Mortality

A recent Environmental Protection Agency (EPA) study analyzed peer-reviewed research on the linkage between adult blood lead level and cardiovascular mortality.[14] Based on this research, the Environmental Defense Fund (EDF) calculated that every lead service line replacement performed in the United States yields an estimated $22,000 in reduced cardiovascular disease deaths.[15] This analysis uses an estimated "value of a statistical life," and is therefore more theoretical in nature when compared to "cashable" savings and economic value generated from other topic areas included in the calculator. However, we recognize that CVD mortality is indeed a real and costly health issue in the United States, and the value of a statistical life is relevant for policymaking in the public health sector. To include this analysis in the lead calculator, we

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[9] Gould, E. (2009). Childhood lead poisoning: conservative estimates of the social and economic benefits of lead hazard control. Environmental health perspectives, 117(7), 1162-1167.

[10] Nichols, G. A., Bell, T. J., Pedula, K. L., & O'Keeffe-Rosetti, M. (2010). Medical care costs among patients with established cardiovascular disease. The American journal of managed care, 16(3), e86-e93.

[11] Lanphear, B. P., Rauch, S., Auinger, P., Allen, R. W., & Hornung, R. W. (2018). Low-level lead exposure and mortality in US adults: a population-based cohort study. The Lancet Public Health, 3(4), e177-e184.

[12] Navas-Acien, A., Guallar, E., Silbergeld, E. K., & Rothenberg, S. J. (2007). Lead exposure and cardiovascular disease—a systematic review. Environmental health perspectives, 115(3), 472-482.

[13] Staessen, J. A., Thijs, L., Yang, W. Y., Yu, C. G., Wei, F. F., Roels, H. A., ... & Zhang, Z. Y. (2020). Interpretation of Population Health Metrics: Environmental Lead Exposure as Exemplary Case. *Hypertension*, *75*(3), 603-614.

[14] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NCEE&dirEntryID=342855

[15] http://blogs.edf.org/health/2020/02/20/lslr-reduced-cardiovascular-disease-deaths/

equate one lead service line replacement to one home lead-based paint remediation. The value of CVD mortality prevention is performed over 35 years after remediation to match the timeframe of the EPA analysis. EPA originally used the 35-year timeframe to capture a full timeline of implementing the lead and copper rule revisions and lead service line installation and maintenance.[16] We present the value of avoided CVD mortality across the 35-year timeframe, starting at age 18. The annual cashflows are calculated from the single lump sum of $22,000 (USD 2016) per remediation, which is what EDF based on estimated number of avoided CVD deaths, Value of a Statistical Life, and other inputs as described in EDF's comments to the EPA Lead and Copper Rule.[17] We update these figures for 2020 USD.

Attention Deficit Hyperactivity Disorder (ADHD)

According to the CDC, 9.4% of children ages 2 to 17 have ADHD.[18] We apply this rate in our target population and assume that 21.1% of ADHD cases are linked to blood lead levels above 2 µg/dL.[19] We adjust Gould cost estimates to 2020 dollars.

Special Education

Research indicates that as high as 20% of individuals with blood lead levels above 25 µg/dL will have special education needs. We apply an avoided annual cost of special education, adjusting Korfmacher (cited by Gould) estimates to 2020 dollars.

Crime

Gould uses data linking crime and lead poisoning from Nevin, crime rates from the FBI, and crime costs from the Bureau of Justice Statistics to estimate the cost of crime linked to lead poisoning. For the calculator, we update FBI crime rates based on 2018 data[20] and adjust crime costs to 2020 dollars. We note that on average, crime rates have fallen substantially since 2006 which has reduced the overall cost of lead poisoning in this area in the past decade.

Earning Potential

The largest benefit of lead poisoning prevention is the increase to earning potential for an individual. Gould calculates that one IQ point loss represents a loss of $17,815 in present value

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[16] https://www.govinfo.gov/content/pkg/FR-2019-11-13/pdf/2019-22705.pdf

[17] https://beta.regulations.gov/document/EPA-HQ-OW-2017-0300-1442

[18] Centers for Disease Control and Prevention. [Data Table]. *Data and Statistics about ADHD*. Retrieved from: https://www.cdc.gov/ncbddd/adhd/data.html

[19] Braun, J. M., Kahn, R. S., Froehlich, T., Auinger, P., & Lanphear, B. P. (2006). Exposures to environmental toxicants and attention deficit hyperactivity disorder in US children. Environmental health perspectives, 114(12), 1904-1909.

[20] Federal Bureau of Investigation. [Data Table 16]. *2018 Crime in the United States*. Retrieved from: https://ucr.fbi.gov/crime-in-the-u.s/2018/crime-in-the-u.s.-2018/tables/table-16

2006 US dollars[21]. We adjust this to 2020 US dollars and back out an annual sum of lost income for each year between an individual's age 18 to 65.

Tax Revenue

As earning potential increases from the prevention of lead exposure, so does income tax generated to local, state, and federal governments. The calculation of federal tax revenue and state and local tax revenue depends on the tax rates entered by the user under the Program Operations Assumptions section.

Energy Savings

The monetary value of energy savings is often realized directly by the family residing in the property and can result in an increase in disposable income; energy savings and health benefits are often referred to as "co-benefits" of healthy housing remediation. We draw from Nevin et al.[22] for estimates of annual energy savings that result from lead-safe window replacement. We take the average annual savings figures and adjust from 2005 to 2020 dollars.

[21] Gould, E. (2009). Childhood lead poisoning: conservative estimates of the social and economic benefits of lead hazard control. Environmental health perspectives, 117(7), 1162-1167.

[22] Nevin, R., Jacobs, D. E., Berg, M., & Cohen, J. (2008). Monetary benefits of preventing childhood lead poisoning with lead-safe window replacement. Environmental research, 106(3), 410-419.

Program Cost Inputs

There are several inputs on the program cost side, allowing the user to customize assumptions to match a planned intervention model as closely as possible. To allow some degree of customization, we separate intervention cost inputs into two tiers, as described below.

Program Cost: Calculator Inputs

> **Average cost per lead risk assessment:** This line item is meant to cover the initial home-based lead risk assessment that occurs once a home is enrolled into the program. The cost of this line item is therefore incurred for every home that is enrolled.

> **Average cost of tier 1 remediation:** We enable the ability to differentiate tiers of remediation for programs that stratify intervention services by intensity. For example, tier 1 remediation may represent a baseline intensity set of services such as remediation of lead-based paint hazards but not replacement of lead service lines.

> **Probability of requiring tier 1 remediation:** Because intervention services are based on assessment and need, we include an input for expected frequency that each tier of service will be performed. This input is the expected frequency that homes will require tier 1 remediation services.

> **Average cost of tier 2 remediation:** If the user applies a tiered remediation approach where tier 1 represents a set of lower intensity services, tier 2 represents a mutually exclusive set of higher intensity services. The average cost of tier 2 remediation would likely be higher than that of tier 1. For example, if tier 1 represents lead-based paint remediation, tier 2 could represent lead service line replacement, in addition to the lead-based paint remediation.

> **Probability of requiring tier 2 remediation:** As with tier 1, this input reflects the frequency in which tier 2 services would be performed.

> **Overhead variable costs, percent of direct costs:** As with many program budgets, this input allows the user to assume an overhead cost as percentage of direct costs (costs of intervention).

> **Variable program costs in operating year, per home:** This input can be used for any program budget costs that are incurred for each home but are separate from tier 1 and tier 2 intervention costs.

> **Fixed program costs in operating year:** This input can be used for any program budget costs that are recurring every year of program implementation. These costs are fixed and independent of number of homes served.

Transaction Costs

Transaction costs for the project encompass evaluation and financing costs. For projects in early development, these inputs can be ignored and set to zero. For project designs that include evaluation or financing components, this section allows the user to enter assumptions for those costs.

Transaction Costs: Calculator Inputs

- **Bond origination fees, percent of total value:** If the project will be financed through a bond issue or similar arrangement, this input allows the user to enter transaction costs as a percentage of program cost. Program cost is defined as all costs entered under the Program Cost section of the calculator.
- **Annual evaluation:** This input represents an annual evaluation cost to the project. This cost is applied to the project each year for the number of years specified in the Program Design section of the calculator.
- **Annual program management:** This input represents an annual program management cost to the project. In some cases, this cost may represent a third-party organization who acts as an intermediary or project manager. This cost is applied to the project each year for the number of years specified in the Program Design section of the calculator.
- **Annual transaction management:** This input represents an annual transaction management cost to the project. If the project is financed through a bond or other financing arrangement, there will likely be a third-party who incurs cost for acting as a fiscal intermediary to manage flow of funds between all parties. This cost is applied to the project each year for the number of project management years.

Other Inputs

Other Calculator Inputs:

- **Discount rate:** This rate is used for calculating present values of future cash flows.
- **Inflation rate:** Where applicable, this rate is used to calculate annual increases in costs due to inflation.

Calculator Outputs

Summary

The economic summary provides a high-level view benefits and costs for the project and on a per-home and per-enrollee basis. Summary metrics are shown on a present value basis and “non present value” basis to highlight the impact of the long time horizon of realizing savings and benefits.

Summary Outputs

- **Total Value of Benefits, PV:** Present value of benefits that accrue from the program.
- **Total Costs, PV:** Present value of costs that accrue to the program.
- **Net of present values:** Net project value after subtracting total costs from total value of benefits.
- **Return on investment:** This ratio takes the net of present values and divides it by the total cost. In other words, ROI = (Benefits-Cost)/Cost. An ROI greater than zero indicates that a project creates more benefit than its cost.
- **Internal rate of return (IRR):** IRR is a financing metric that is used in comparison to a hurdle rate that would indicate whether a project should be undertaken. Investors and funders often take more stock in IRR versus ROI because IRR considers the timing of cash flows whereas ROI does not.
- **Chart: Annual Cash Flows of Intervention Benefits by Category:** This chart shows cash flows of benefits that are generated by the project over time. Note that the cash flows from earnings begin at age 18, which results in increased earnings to the individual and increased tax revenue to government. The calculator includes a cash flow chart on a project-basis and per-person basis.
- **Chart: Present Value of Intervention Benefits:** This chart shows present value of total benefits by category on a project and per-person basis.

Below are example outputs. Table 1 is an example output chart showing a single enrollment cohort of 200 homes. Chart 1 shows the value of prevention across all areas across the entire term of a project.

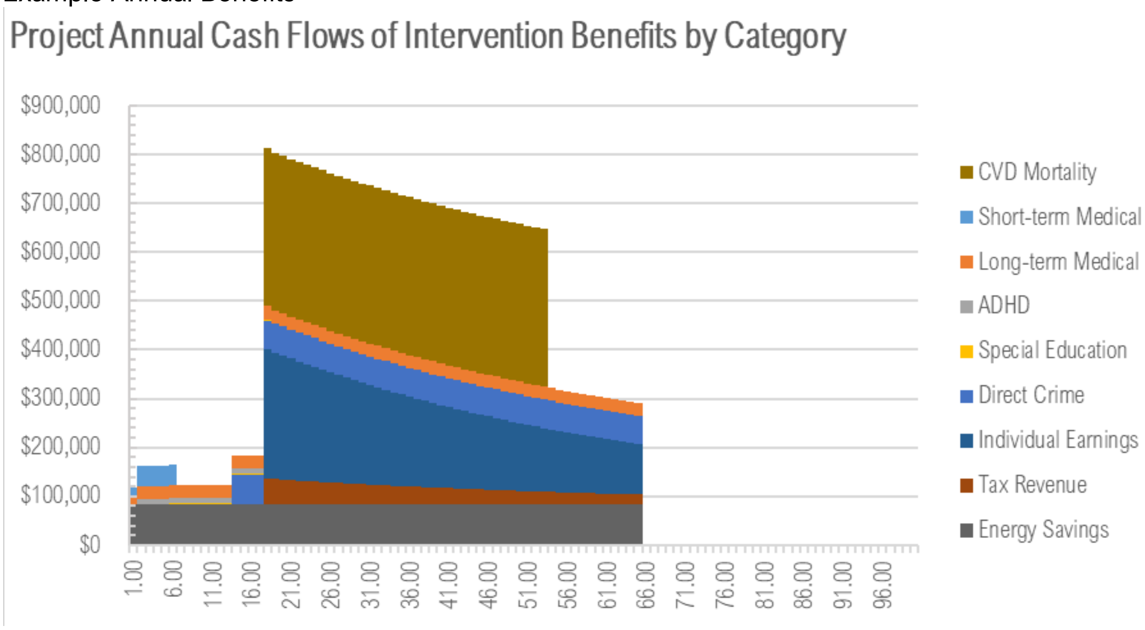
Table 1

Example Output Table

	Summary	Total	Per Home	Per Enrollee
Present Value	Total Value of Benefits, PV	15,627,759.94	$78,139	$41,785
	Total Costs, PV	(3,041,750)	($15,209)	($8,133)
	Net of present values	$12,586,010	$62,930	$33,652
	Return on Investment	413.78%		
	Internal Rate of Return	8.94%		
Non-PV	Total Value of Benefits	$30,324,152	$151,621	$81,081
	Total Costs	($3,041,750)	($15,209)	($8,133)
	Net Benefits	$27,282,402	$136,412	$72,948
	Return on Investment	896.93%		

Chart 1

Example Annual Benefits



Conclusion

It is our hope that the Lead Financing Calculator is a helpful resource for jurisdictions and stakeholders looking for practical ways to finance prevention programs. GHHI continues to advocate for evidence-based, innovative approaches for combatting lead poisoning using a toolbox of strategies, from policy to financing to program implementation.

We welcome all feedback about this resource and look forward to a continued conversation with partners in the healthy housing field. Please do not hesitate to contact GHHI with questions or comments.