February 2018

FAQ:

Policies to Prevent and Respond to Childhood Lead Exposure Project

Social Genome Model FAQ

Q: Why was the Social Genome Model (SGM) chosen for this analysis? How do we know its results are valid?

A: Policymakers often lack reliable information on the likely impacts of policies intended to promote upward mobility and enhance well-being. This includes information about the effects of an intervention, whether one policy administered with the same target population is more or less effective than another, whether the timing of interventions matters, or whether multiple interventions—concurrent or sequential—have notably bigger impacts than single ones.

The SGM is a dynamic microsimulation model, that is, a computer program that mimics the operation of government policies, public and private programs, and demographic processes on individual ("micro") members of a population. The SGM was developed to provide estimates of such information in a variety of contexts. The model starts at birth and moves through five subsequent life stages—early childhood, middle childhood, adolescence, transition to adulthood, adulthood— through age 40. The SGM models outcomes such as high school graduation rate, likelihood of teen parenthood, likelihood of a criminal conviction, and lifetime earning using an individual's circumstances at birth and experiences growing up. Individuals at each life stage are characterized by variables that were chosen after a review of the literature on child development and human capital, as well as with advice from experts in the field.

The SGM developers reviewed any empirical evidence for measures that predicted later success, assessed the availability of data on the measures, and sought advice from experts on lead exposure and child development. The variables and the success measures also reflect both cognitive and noncognitive skills in early and later childhood. The data used in the SGM come from large-scale, federally funded longitudinal surveys. The SGM developers adopted numerous approaches to verify that the SGM uses data that plausibly represent a contemporary and representative group of children, and estimated relationships that plausibly represent the experiences they will have as adults.

Q: What are the data sets and variables used in the SGM to simulate the effect of lead exposure in children?

A: The version of the SGM used for this research was constructed using two data sets from the Bureau of Labor Statistics' National Longitudinal Surveys: the Children of the National Longitudinal Survey of Youth (CNLSY) and the National Longitudinal Survey of Youth 1979 (NLSY79). The CNLSY data we used follow children from birth through age 19; those children were born to the women of the National Longitudinal Survey of Youth 1979 (NLSY79). Most of the children in the CNLSY were born in the 1980s or early 1990s. The NLSY79 followed a sample of people in the United States born between 1957 and 1964 from their first interview (ages 14 to 22 in 1979) into mid-adulthood.

The SGM combines the data sets and statistically matches individuals in the CNLSY (information about children through age 19) to individuals in the NLSY79 (information about adults 29 to 40). In this case, the SGM used CNLSY and NLSY data to track the impact of lead exposure prevention and response interventions on early and middle childhood reading scores, math scores, hyperactivity measures, and antisocial behavior measures. The outcome variables were high school GPA, likelihood of earning a high school diploma by age 19, teen pregnancy, criminal conviction by age 19, likelihood of a 4-year college degree by age 29, family income at age 40, and lifetime family income.

Q: How did the model estimate the effects of the policies to prevent lead exposure?

A: The team first identified the magnitude of the effects of the individual policies on children's blood lead levels, using published literature and in consultation with the project's expert advisors. Separately, the team identified the magnitude of the relationship between changes in children's blood lead levels and the relevant variables in the SGM—early and middle childhood reading and math scores, hyperactivity, and antisocial behavior. Because the SGM does not include a measure of children's blood lead levels, the modeling team used demographic and economic variables to assign a blood lead value to every person in the SGM cohort using statistical analysis (i.e., imputation), to align the population blood lead levels with the distribution of blood lead levels nationally as estimated in the 2012 and 2014 National Health and Nutrition Examination Survey (NHANES).

The assigned blood lead values were first used to determine if a person in the model would "receive" the policy intervention, and then to determine by how much their reading, math, and behavior would change as a result of receiving the intervention. The team modeled the policy effects by directly altering the values of the early and middle childhood outcome scores (reading, math, and behavior) to the degree that the literature suggests given the change in blood lead levels resulting from a given policy intervention. For example, if a child in the SGM has a blood lead level of 1.5 µg/dL and is in the target population to receive a policy intervention that prevents a 50 percent increase in blood lead, his or her blood lead should be 0.75 µg/dL lower than without the intervention. Using the expected reading score effect size, estimated from the evaluation literature, of a 0.0405 standard deviation increase in reading score for every 1 µg/dL decrease in blood lead, this child's reading score would improve by 0.0304 (i.e., 0.75 x 0.0405) standard deviations. Once the reading, math, and behavior scores were directly altered by the appropriate amount, the SGM was run to estimate how these changes would affect the person's later outcomes, such as high school graduation and family income at age 40.

Q: Why do the simulations using the SGM focus on changes in blood lead levels through reading, math, and behavior?

A: The research literature finds that exposure to lead reduces children's cognitive ability and contributes to behavioral problems. The measures in the SGM that are most closely related to those factors are academic achievement (reading and math) and behavior (hyperactivity and antisocial behavior). Research has found that, after controlling for other factors, children with lower blood lead levels have better early reading scores than those with higher blood lead levels.[1] The research literature that links childhood blood lead levels to reading and math scores often includes data for very large school districts and even whole states. This means that sample sizes can run in the tens of thousands, so we can have a relatively high level of confidence in the precision of the estimates.

During their preschool and early school years, lead-exposed children struggle to focus in the classroom, experience poor impulse control during tasks, display disruptive behavior, are more likely to be diagnosed with a learning disability, and struggle to pass achievement tests. Lead exposure has also been found to reduce IQ as well as academic achievement. These deficits become risk factors for

[1] Lisa Chiodo et al., "Blood Lead Levels and Specific Attention Effects in Young Children," *Neurotoxicology and Teratology* 29, no. 5 (2007): 538–46, https://doi.org/10.1016/j.ntt.2007.04.001

future delinquency, criminal behavior, substance use, and teen sexual risk-taking and pregnancy as exposed children enter adolescence and young adulthood.[2]

Q: What were the findings from the SGM modeling of the lead exposure prevention policies?

A: Based on the modeling outcomes, we found that lead exposure prevention policies would improve the academic and social outcomes of children as well as their lifetime family income. It is important to remember that the outcomes are for all children who live in targeted areas or homes, not all of whom necessarily have high blood lead levels. For the subset of children with high blood lead levels, the effects are, of course, larger than for the overall population. This information appears on page 99 of the report along with further discussions of the outcomes.

Q: How much uncertainty is there around the SGM estimates included in the report? Were any sensitivity analyses conducted?

A: A description of the modeling uncertainty and sensitivity analysis appears on pages 110-114 of the report, and we provide a summary here. First, the certainty of the estimated impact of each intervention on childhood blood lead levels that we modeled varies due to the robustness of available data, or the availability of data at all. For example, for the lead service line replacement intervention, the modeling team relied on surveys of utility companies to determine the number of lead service lines in the country. The modeling team estimated the number of children who might be served by the lead service lines, since there are no data documenting an exact number. Data on the effects of lead hazard control interventions are more robust and recent.

Second, selection into the target population for an intervention was based on imputed blood lead levels, which introduced a measure of random variation. The modeling team offset this random variation by taking the average of repeated simulation trials. For each of the four SGM samples (black male, black female, nonblack male, nonblack female) the modeling team ran 10 simulations with changing randomization seeds, for a total of 40 runs, to produce estimates of effects for each policy intervention.

Finally, the effect of blood lead levels on childhood academic, behavior, or IQ outcomes are based on regression analyses on observational rather than random-assignment data. The studies statistically control for variables such as gender, race, and socioeconomic status, which mitigates but cannot eliminate any over- or under-estimating of the relationship between lead and childhood outcomes. The same uncertainties exist for the relationship between childhood outcomes and later life outcomes.

As a sensitivity analysis, the modeling team used bounding exercises to determine the extent to which an intervention could impact a child's blood lead levels. The team estimated what would happen if every child's blood lead level was 0 ug/dL, which might be difficult to achieve due to the naturally occurring minute levels of lead in the general environment, but which provides an upper-bound estimate of the effects of lead exposure prevention. The model indicated that holding blood lead levels at zero would improve high school and college graduation rates, and decrease rates of teen parenthood and criminal conviction.

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[2] Center for Disease Control and Prevention. *Educational Services for Children Affected by Lead Expert Panel. (Educational interventions for children affected by lead.* Atlanta: U.S. Department of Health and Human Services, 2015.), accessed December 15, 20166, https://www.cdc.gov/nceh/lead/publications/educational_interventions_children_affected_by_lead.pdf

Q: What other applications/interventions has the SGM been applied to?

A: Child Trends and the Urban Institute, along with their partners at the Brookings Institution, have been developing, maintaining, and running policy simulations on the Social Genome Model for the past four years. Findings from the model have been published in peer-reviewed journals.[3,4] For example, in November 2016, the research team published an article in the Journal of Social Insurance for which they used the model to show the possible long-term benefits of intervening early and often for the future economic prospects of children born into families with low incomes. Additionally, the SGM has also been used to analyze policies for the White House Council for Women and Girls under a contract with the U.S. Department of Labor's Women's Bureau, for the "My Brother's Keeper" initiative, and for the Bridgespan Group's Big Bets to Create Opportunity for Every American project.

Q: How did the modeling team choose the academic and behavioral response interventions used to support children with a history of lead exposure?

A: In the report, academic and behavioral response interventions are tactics to mitigate the impact of lead exposure in children. The modeling team selected the response intervention evaluations based on a literature search, recommendations, and the use of various online compendia such as Child Trends' What Works/LINKS database and the Blueprints Programs compendium. The modeling team identified high-quality early and middle childhood response intervention programs aimed at enhancing the academic and behavioral development of children to identify the median effect size across the interventions. These programs are implemented in schools or out of schools, and with parents, teachers, or caregivers. To have been included in the analysis, most of the intervention evaluations had to be random assignment evaluations with an intent-to-treat analysis. In addition, the programs had to have been conducted with children in either their early or middle childhood years, and to have reported on one or more outcomes in the SGM—academic, behavioral, or both.

Q: How did the modeling team determine the effect sizes of the academic and behavioral response interventions used in the modeling of the interventions to support children with a history of lead exposure?

A: To determine the effect size of the interventions on the academic and behavioral outcomes, the modeling team initially categorized the identified programs by whether they measured outcomes in either early childhood (0 to 5 years old) or middle childhood (6 to 11 years old). The team calculated effect sizes (specifically, Cohen's *d*[5]) or used the effect sizes reported in the study for any outcomes related to reading scores, math scores, hyperactivity, and antisocial behavior. For example, Weiland and Yoshikawa (2013) found that implementation of reading and math programs improved reading skills for children by 0.42 of a standard deviation.[6] For antisocial behavior, the effect sizes for related outcomes such as conduct disorder, aggression, or disruptive behavior were all included. Because some of the programs were implemented over a period of time, which resulted in data that were collected in waves, we only included the final outcome measures. In cases for which a program evaluation measured multiple aspects of a particular behavioral or academic outcome, we calculated the mean effect size for that outcome in that intervention. To determine the overall effect size of the early childhood and middle childhood interventions on academic and behavioral outcomes, the modeling team used the median value across all of the program evaluations for each relevant outcome in the SGM (reading, math, hyperactivity, and antisocial behavior).

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[3] Isabel V. Sawhill and Richard V. Reeves, "Modeling Equal Opportunity," *The Russell Sage Foundation Journal of the Social Sciences*, 2 no. 2 (2016): 60–97

[4] Gregory Acs, Steven Martin, Jonathan A. Schwabish, Isabel V. Sawhill, "The Social Genome Model: Estimating How Policies Affect Outcomes, Mobility and Inequality across the Life Course," *Journal of Social Issues*, 72, (2016): 656–675. doi:10.1111/josi.12188

[5] Becker, L.A (2000). Effect Sizes (ES). University of Colorado, Colorado Springs, CO. Retrieved online: https://www.uccs.edu/lbecker/effect-size.html

[6] Weiland, C., & Yoshikawa, H. (2013). Impacts of a prekindergarten program on children's mathematics, language, literacy, executive function, and emotional skills. *Child Development, 84*(6), 2112-2130.

Q: How were the effect sizes used in the SGM?

A: The effect sizes of early and middle childhood response interventions were used in the SGM to simulate lifetime outcomes under the assumption that the response programs used to derive the effect sizes are provided to all children with blood lead above 2.0 µg/dL at ages 1 to 5. Because the SGM does not contain information on children's blood lead, we used data from NHANES to assign blood lead levels to children based on their social and demographic characteristics, then modeled program effects by directly altering the values of the early and middle childhood outcome scores (reading, math, and behavior) to the degree that the evaluations of the programs suggest. For example, if a child in the model was in the target population for an early childhood education and care response intervention (i.e., had a blood lead level estimated to be above 2.0 µg/dL), the child's reading score was increased by 0.24 of a standard deviation, which is the average effect size based on the early childhood evaluation literature that was reviewed by the modeling team. Once the reading, math, and behavior scores were directly altered by the appropriate amount, the SGM was run to estimate how these changes would affect the person's later outcomes, such as high school graduation and family income at age 40.

Q: What were the findings from SGM modeling of academic and behavioral response interventions to support children with a history of lead exposure?

A: From the modeling, we predicted that when children with blood lead levels of 2 ug/dL or higher were enrolled in early and middle childhood education and care response interventions, they would experience improved outcomes in their adolescence and as adults. We predicted that they would have higher GPAs, and reduced likelihood of pregnancy or criminal conviction by 19. Finally, the model predicted that, at age 40, the annual income of those who, as children, had participated in the programs, would be $10,000 higher than the income of those who did not participate in either early or middle childhood programs. In addition, children who participated in both early and middle childhood response interventions would have, by age 40, a lifetime family income (since reaching adulthood, till age 40) of $102,000 greater than those who did not participate in either.

Value of Prevention Tool FAQ

Q: Why was the VP Tool chosen for this analysis? How do we know its results are valid?

A: The VP Tool is useful for synthesizing knowledge of the short- and long-term benefits of an intervention to prevent disease or disability in a target population. It was designed to estimate these benefits over time across a number of dimensions—morbidity, mortality, health care costs, earnings, and incarceration costs. It also allows these benefits to be allocated to federal government, state and local governments, and society as a whole. These were all important features for this analysis.

The validity of the tool rests primarily on the validity of the data it employs to make these estimates, and the study included a careful analysis of the validity of the available data to ensure that the most valid data were used. Previously, the VP Tool has been used to assess the value of smoking prevention, obesity prevention, early childhood interventions such as perinatal care and early childhood education, and prevention of opioid abuse.

Q: What interventions to reduce lead exposure did the study team model, and why did they choose those interventions?

A: The VP Tool was used to estimate the benefits of removing leaded drinking water service lines in homes; eradicating lead paint hazards from older homes; ensuring that contractors employ lead-safe renovation, repair, and painting practices; and eliminating lead from airplane fuel. These interventions were selected based on an assessment that they were among the most effective interventions available in terms of their impact on reducing lead exposure among young children, and because adequate data were available to develop credible estimates of their impact. Other interventions, such as removing lead from food and consumer products or removing lead pipes from drinking fountains in schools, were more difficult to model because of lack of data and because they were thought to address less significant sources of lead exposure than the interventions that were modeled. The study team did, however, conduct qualitative assessments of the potential impacts of these interventions.

Q: What was reducing an elevated blood lead level assumed to affect? What types of benefits of such a reduction were included in the VP Tool calculations, and what benefits were excluded or missing?

A: Elevated blood lead levels have an adverse effect on physical health and cognitive well-being. Lowering these levels therefore improves health, reduces healthcare costs, increases educational and employment opportunities, and reduces criminal behavior and incarceration rates. The VP Tool measured these benefits through its model that estimated increased lifetime earnings, reduced health expenditures (both short-term costs associated with dealing directly with lead exposure, and long-term costs associated with a change in the prevalence of cardiovascular disease), decreased education spending, and a lower risk of mortality. The benefits included in these calculations were primarily economic in nature and did not capture emotional distress or other costs to families, such as time away from work. Also excluded were the impacts of criminal behavior beyond incarceration costs. Additionally, the benefits of home remediation (lead hazard control and lead service line replacement) did not capture benefits to visitors or adults, only the benefits to resident children.

Q: What baseline blood lead levels were used in the VP Tool, and how were they estimated?

A: Baseline blood lead levels are the blood lead concentrations assumed for the 2018 birth cohort in the absence of a new policy or intervention to eliminate lead or reduce childhood exposure. These levels serve as a hypothetical comparison group for the intervention scenarios modeled in the report. The baseline distributions of blood lead levels used in the VP Tool include both the likely number of children exposed and the severity of that exposure, based on data from the National Health and Nutrition Examination Survey (NHANES), a nationally-representative survey of children and adults that tests numerous health and nutrition characteristics of the U.S. population. We used data from children aged 1 to 5 from a combination of the two most recently available NHANES surveys, 2012 and 2014, to develop our baseline estimates. These estimates were calculated using NHANES sample weights and partitioned by demographic characteristics when included in the VP Tool.

Q: How were the costs of these interventions estimated? Are program/administrative costs included in the estimated cost of each intervention?

A: The costs of the lead hazard control, lead service line replacement, and renovation, repair, and painting standard enforcement were estimated through a combination of analyses of previously administered programs and expert consensus. Whenever possible, real costs from intervention programs similar to those proposed in the report were used to estimate the costs of the hypothetical, modeled interventions, and previous cost estimates were inflated to today's dollars when necessary. However, in some cases, such as lead service line replacement, previous costs varied significantly and only a limited number of comparable interventions were available at the time of the report to help us produce an estimate. In these cases, we also included data from expert consensus to estimate the cost to remediate an average home. In all cases, testing costs were applied to all homes and only a certain percentage of homes were estimated to require remediation. For some interventions, such as the elimination of lead from aviation fuel, cost estimates were not available, and in these cases, we modeled only the potential benefits. Program costs and administration costs were not included in the estimates due to uncertainty over who would administer the proposed interventions and the scale of the programs.

Q: Why are benefits only calculated for one annual cohort of births?

A: Reporting benefits for a single birth cohort helped ensure consistency across policies and allows readers to compare these results to previous work in which the focus was also a single cohort. Estimating benefits for additional cohorts would also introduce greater uncertainty in the results, because it would require predicting blood lead levels and other characteristics further into the future. However, many of the policies studied would be implemented and accrue benefits over a longer period, leading to additional benefits that were not modeled.

Q: To what extent and how can these cost and impact estimates be extrapolated to other populations? Can the benefits for a single cohort be multiplied to produce estimates for an intervention spanning multiple years?

A: Yes, in general, it is possible to extrapolate from this analysis the likely impact of interventions for a broader population, including children born in years beyond the birth year of the initial cohort. An intervention on a similar population would be expected to provide benefits to a similar number of children and at magnitudes similar to the benefits to the cohort modeled in the report. Over time, however, if an intervention were replicated for many years, it would be expected that the stock of homes or service lines would improve and a smaller percentage would require remediation. Additionally, assumptions about baseline blood lead levels become more uncertain further into the future, impacting the potential benefits of an intervention many years from now. One can estimate that the impact of an intervention over the next two years might result in roughly twice the impact of an intervention for a single cohort. However, estimating the impact of an intervention for the next 10 or 20 cohorts would be far more difficult to do with any reasonable degree of certainty.

Q: Why are the health and education benefits small when compared to improved future earnings?

A: Lifetime earnings benefits were represented in the VP Tool using literature that (1) related reduced blood lead levels to increased IQ levels and (2) related IQ levels to lifetime earnings. These latter effects are large partly because they accrue over an entire life history of employment and partly because they affect (to a greater or lesser extent) all individuals whose exposure to lead is reduced.

In contrast, education benefits are limited to the much smaller number of individuals who are required to repeat grades or require special education in the absence of a reduction in lead exposure. Similarly, health benefits accrue to a relatively small number of individuals who would otherwise require treatment for excessive lead exposure or who would otherwise develop cardiovascular disease later in life as a result of exposure to lead. Not only do these health and education benefits accrue to a relatively small subset of the entire population to whom the modeled interventions apply, but they also accrue over a shorter period of time than do lifetime earnings.

Q: How do the results compare to those for other childhood interventions such as vaccines, preschool education, food assistance, or poverty alleviation?

A: The modeling results of this report show lead remediation and prevention interventions are likely to return benefits greater than initial costs in the long run. Other early childhood interventions, such as vaccinations and early childhood education, have also been shown to have positive cost-benefit ratios and benefits of improved health, life expectancy, education, and lifetime earnings. For example, high-quality preschool has been estimated to return $7 to $10 per dollar invested, but it is difficult to directly compare interventions like this to lead prevention and remediation.[7] Any intervention may have different benefits for different children.

While cost-benefit ratios should never be the sole deciding factor in determining funding allocations for childhood interventions, the results of this report show the potential for significant societal returns from most of the proposed lead elimination interventions.

Q: Why were benefits only calculated for previously unexposed children? What about those already exposed to lead? What about adults exposed to lead?

A: The benefits of reducing lead exposure were modeled only for a hypothetical future birth cohort due to data limitations and to emphasize the importance of primary prevention. While many of the interventions would likely provide benefits to both previously exposed and unexposed children and adults living in the home, effect sizes and subsequent benefit calculations are only possible for previously unexposed children. We are not aware of studies analyzing the impact of reducing future blood lead levels, for a child who has already been exposed to toxic levels, on IQ, health, or lifetime earnings. Instead, the studies we relied on for our estimation compare outcomes between those exposed at higher levels to those of children exposed to lower levels of lead. It would be very difficult to plausibly estimate the impact of an intervention for an already-exposed child. For this reason, we limited our analysis to the value of preventing exposure for the future cohort. Further, while benefits to reducing adult exposure have been shown, these impacts are generally shown at blood lead levels so high that they are not readily observed in today's population.

Q: What does it mean to discount future benefits, and why is it important?

A: Discounting is used to reflect the fact that a fixed amount of money today is worth more than that same amount in the future: the investment of that money now would result in a greater amount of money in the future than it would if that initial sum were made available at that future date. Discounting captures this lost opportunity for future gains.

[7] Heckman, James J., Seong Hyeok Moon, Rodrigo Pinto, Peter A. Savelyev, and Adam Yavitz. "The Rate of Return to the High/Scope Perry Preschool Program." *Journal of Public Economics, 94*(1): 114-128.

Q: How uncertain are the estimates of costs and benefits?

A: The modeling process cannot compute traditional statistical measures of uncertainty like standard errors and confidence intervals. However, we performed sensitivity analyses of certain coefficients, and included those in the methodological appendix of the report. We prioritized coefficients for study in the sensitivity analyses based on importance in the modeling and relative impact on the final results.

Q: Why was the study conducted as a cost-benefit analysis rather than (for example) a cost-effectiveness analysis or a return-on-investment analysis?

A: Cost-benefit analysis is most appropriate when viewing an intervention from a societal perspective (i.e., when the analysis considers the costs and benefits of the intervention from the perspective of society as a whole) and when the benefits are all expressed in dollars. Cost-effectiveness analysis is also appropriate for a societal perspective, but is used when benefits are expressed in non-monetary units, such as life years gained from the intervention. Return-on-investment analysis expresses all benefits in dollars, but is most appropriate when considering the benefits and costs from the perspective of a specific investor, rather than from the perspective of society as a whole. Because the analyses conducted with the VP Tool emphasized economic benefits and employed a societal perspective, cost-benefit analysis was deemed the most appropriate approach.

Q: How do the VP Tool estimates compare to previous estimates?

A: In comparing results of the total impact of childhood lead exposure to other estimates in the research literature, the VP tool produces very similar findings. In general, this modeling effort used the most recent studies indicating lower starting blood lead levels but larger effect sizes for childhood exposure, offsetting to produce similar totals. In the analysis of particular interventions, the VP tool showed somewhat smaller relative returns for those investments. This likely results from having different starting assumptions and different methodologies. For example, some previous work has estimated the potential impact of lead hazard control interventions while assuming removing lead from paint could remediate the entire societal burden of childhood lead exposure. We did not make this assumption, and instead estimated the exposure risk from each single source and the subsequent benefits of any single intervention (given the multiple potential sources of lead exposure). This likely caused the somewhat smaller cost-benefit ratios produced in this work.

Q: How do the VP Tool estimates compare to estimates from the SGM modeling?

A: While the VP Tool and SGM modeling efforts were distinct, used slightly different theoretical populations, and produced estimates of different outcomes in different formats, when compared on dimensions such as earnings, they produced similar results. In general, the VP Tool showed somewhat larger relative impacts on lifetime earnings, likely due to the fact the VP Tool was driven by the impact of lead exposure on IQ, whereas the SGM modeling was driven by the impact of lead exposure on academic outcomes like math and reading scores. Where the impacts varied, the different literature used to develop effect sizes was the likely dominant cause. However, given the completely independent origins of the two modeling tools, the fact that they produced comparable results provides credibility for both models.

General Modeling FAQs

Q: What data issues limited the analysis? What would constitute an ideal data set for this purpose and how might it be developed?

A: The primary data limitations were the lack of longitudinal data sets tracking the lifetime outcomes of children including collected childhood blood lead levels, the limitations of studies that directly measure the impacts of primary prevention interventions such as removing lead from consumer products on blood lead levels, and the limitations of studies quantifying how many children are affected by different sources of lead. As a result, stepwise modeling strategies were required, predicting lifetime impacts based on the relationship between blood lead levels and IQ, and intervention impacts based on the relationship between an intervention and environmental lead levels. An ideal data set for studying lead impacts and interventions, although expensive to construct, would be a combination of childhood blood lead level measurements, concurrent environmental lead levels, and longitudinal data on long-term outcomes like health, employment, income, and incarceration.

Q: Can the results be used to compare the different possible interventions?

A: Each intervention was modeled independently, and while similar assumptions were made for each analysis, we caution against direct comparisons between interventions based on these results. In general, when the results for an intervention show a positive impact and societal return on investment, there is support for the potential effectiveness of a program. However, differences between interventions may not be identically comparable in the model results and the potential return on investment should only be one factor in deciding funding allocations for specific interventions.

Q: Can the results of multiple interventions be combined to show the benefits of simultaneous or comprehensive interventions?

A: Because the benefits of each intervention were estimated independently of those from other interventions, there is no straightforward way to estimate the overall impact of multiple interventions applied simultaneously. This is because simultaneous interventions would have complex interacting impacts on lead exposure and resultant blood lead levels, and there is little empirical evidence available to characterize these interactions.

Q: How were the magnitudes of the effect sizes established?

A: The effect sizes used in the modeling (for example, the relationship between elevated childhood blood lead levels and IQ, or the impact of a comprehensive lead hazard control interventions on household dust lead levels) relied on previous academic literature and published estimates. The Health Impact Project research team, supplemented by work of Child Trends and Altarum Institute, performed a literature review of relevant studies of effect sizes, filtered those studies based on quality and study type, standardized the study results, and then produced consensus estimates of effect sizes through an average of the coefficients. Whenever possible, all relevant studies available at the time were included and estimates were partitioned into groups (for example, blood lead level categories) or limited to populations most similar to the modeled cohort. For more detail, see the report's methodological appendix. Tables listing specific studies used for any particular effect size are also available on request.

Q: Is it really feasible to remove all lead, as hypothesized in one of the VP Tool analyses? What is the cost of removing all lead?

A: Removing 100 percent of lead from the environment is likely impossible. This analysis was an exercise to estimate an upper boundary of the benefits that could be achieved from any combination of interventions to reduce lead exposure for a birth cohort of children. Given the infeasibility of actually accomplishing complete removal of lead, there was no accompanying cost estimate. But the fact that these upper-bound benefits are very large lends credence to the argument that interventions that can significantly reduce childhood lead exposure are likely to produce substantial benefits.

Q: How is it possible that most of the benefits from removing lead accrue to children with the lowest blood lead levels?

A: While individual children who would otherwise have high blood levels would benefit the most from avoiding exposure to lead, data from the National Health and Nutrition Examination Survey (NHANES) on exposure levels show that the vast majority of children will likely be exposed to lead at relatively low levels. Only a small portion of the modeled cohort would be expected to reach elevated blood lead levels of 5 or 10 µg/dL. Therefore, while reducing exposure for children with the lowest blood lead levels produces smaller benefits per person, when multiplied by the size of the group, the total benefits for all the lowest-exposure children exceed the total benefits of the much smaller population of children with the highest blood lead levels.

Q: What "action level" (threshold blood lead level) was used to identify children requiring an intervention? What other considerations were used to define the populations assumed to be targeted by these interventions?

A: While threshold blood lead levels have been used to target interventions or designate children as "at risk" for adverse outcomes as a result of their exposure, we rely on the best available literature and expert consensus that has shown there is no safe level of lead exposure for children. If lead exists in a child's home it should be remediated or removed completely, specifically before a child reaches any measurable blood lead level threshold. The only way to completely prevent adverse outcomes is to remove lead from a child's environment before exposure occurs. Therefore, we did not model interventions that were limited to populations with certain blood lead levels. Instead, we modeled interventions that were targeted or prioritized based on environmental risk-factors. We often used cutoffs to identify populations most at risk for exposure based on housing age; lead in residential paint was banned in 1978 and in residential service lines in 1986. Additionally, we used the academic literature to identify the maximum distance from regional airports for which a child receives measurable increases in lead exposure from aviation fuel. These populations were modeled to receive the intervention and receive the hypothetical benefits of reductions in exposure.

Q: How was the impact of these interventions on blood lead level estimated?

A: The size of the impact of an intervention was estimated from previous studies published in the academic literature. Similar to the effect size estimates of the impact of childhood lead exposure on IQ, health, and earnings, we curated intervention impacts through literature review and included relevant studies in our estimates, prioritized by the quality of the study and type of analysis. Whenever possible, we used results from controlled studies, but in some cases intervention impacts were taken from studies that used pre/post-analyses or -modeling. In general, the total impact of an intervention was modeled through the expected improvement in environmental lead levels and the subsequent improvement this would be expected to cause in a child's blood lead levels. More detail on particular intervention coefficients and studies are available in the report's methodological appendix.

Q: Are there nutritional interventions that could have been modeled, and if so, why were they not modeled?

A: Child Trends conducted a literature search on the evidence for an association between nutrition programs and academic or behavioral outcomes for children, and found that the evidence was not sufficient to warrant modeling. A large proportion of the studies only examined the effect of nutritional programs, in particular studies of Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP), on healthy eating habits. In other words, they did not examine child outcomes. Further, the designs of the studies described in the literature were predominantly cross-sectional or cohort studies, with just one random assignment study. Finally, the findings of the studies were not consistent in the direction of the effects of the programs on academic or behavioral outcomes. Some of the studies found that these nutritional programs had a negative effect on reading outcomes, while others showed no difference in outcomes between children who were a part of the control/comparison group compared to those in the treatment groups.

Q: Why were the benefits of removing lead from food (or some of the other policy proposals) not modeled?

A: Other interventions, such as removing lead from food and consumer products, were more difficult to model because of lack of data, and were deemed to be less significant sources of lead exposure than the interventions that were modeled. The study did, however, conduct qualitative assessments of the potential impacts of these interventions.

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