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Valuing Children's Health: A Reassessment of the Benefits of Lower Lead Levels

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Executive Summary

Benefits to parents of lower lead levels in their children are much less than federal regulatory agencies' estimates of benefits, which they compute as the expected discounted gains to children's lifetime earnings. Using earlier work by Agee and Crocker, I show benefits to parents are between $1,100 and $1,900 per IQ point gained, or roughly one-sixth of the benefits to children estimated by federal agencies. The new estimates are superior insofar as they are based on observed behavior. They also use a more robust measure of lead levels in children. This analysis suggests lead standards will redistribute resources from parents to their children, because the benefits to parents are less than the costs of the standards. The Environmental Protection Agency and the Department of Housing and Urban Development should reconsider their lead standards.

Valuing Children's Health: A Reassessment of the Benefits of Lower Lead Levels

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1. Introduction:

Over the last few years, the administration has made children's health an important policy goal. President Clinton signed an Executive Order directing federal agencies to assign a high priority to the identification and assessment of health and safety risks that "disproportionately affect" children and to ensure that policies and programs address disproportionate risks.[1] The heads of the Environmental Protection Agency and the Department of Health and Human Services have given high priority to children's health initiatives.[2]

Policymakers are launching large new programs to protect children's health from exposure to lead, which by some accounts is the "most important pediatric environmental problem in the U.S."[3] The Department of Housing and Urban Development (HUD) recently issued a regulation on evaluation and reduction of hazards related to lead-based paint in federally-assisted housing. In December 2000, the Environmental Protection Agency (EPA) will establish lead hazard standards for private housing. Although these standards will not be federally enforceable, EPA expects compliance to be widespread as a result of actions by lenders, insurance companies and other third parties. States are also taking action. The Maryland Governor's office has recently announced a $50 million plan to dramatically reduce child lead poisoning in Baltimore.[4] These efforts target lead-based paint because it is the source of continuing exposure to children both directly and indirectly through the dust and soil that it contaminates, despite being banned in 1978.

Motivating these programs are data showing that lead still threatens children's health, despite recent dramatic declines in levels of lead in children's blood. According to a recent survey, nearly 900,000 children in the United States between one and five years of age have blood-lead levels above the level of concern established by the Centers for

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[1] See Clinton (1997).

[2] For example, children's health is the only substantive policy goal listed on the homepage of EPA's website at www.epa.gov.

[3] See Bellinger, et al. (1992, p. 855).

[4] See State of Maryland (2000).

Disease Control.[5] Researchers have linked elevated levels of lead in blood to a decline in intelligence as well as to a variety of neurological problems.

Developing sensible policies to protect children from the adverse effects of elevated lead levels requires information about the economic value of reducing exposure to lead. To comply with Executive Order 12866, regulatory agencies have analyzed the benefits and costs of major regulations limiting exposure to lead.[6] Moreover, EPA set its proposed residential lead hazard standards—estimated by the agency to cost $58 billion in present value— to "balance" costs and benefits.[7] After analyzing the Residential Lead-Based Paint Hazards Act of 1992 and its legislative history, EPA concluded "hazards standards should be based on a set of parameters identified by balancing the costs of reducing exposures to hazards with the benefits of avoiding adverse health risks."[8]

EPA and HUD estimate benefits of reducing lead in the bodies of children by relating reductions in blood-lead levels to IQ gains and valuing these according to the effect of higher IQ on lifetime earnings.[9] They take this approach in part because an obvious measure of reduced risk of high lead levels in children—the absence of lead hazards in a home—is generally not associated with higher home values. The agencies calculate that a decline in lead of one microgram per deciliter of children's blood implies a decline in IQ of 0.257.[10] Each drop of one IQ point lowers expected discounted lifetime earnings by 2.4 percent or about $8,800.[11]

This approach has two key shortcomings. First, it is not grounded in the preferences for lower lead levels that people reveal by participating in market transactions, although economists prefer such estimates. Second, it uses levels of lead in blood, which are relatively poor measures of cumulative exposure because blood-lead levels "may return to normal levels even though exposure was excessive."[12]

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[5] See U.S. Centers for Disease Control (1997a).
[6] See, for example, U.S. Environmental Protection Agency (1998a) and U.S. Department of Housing and Urban Development (1999a).
[7] See U.S. Environmental Protection Agency (1998a, p. ES-2). This value and all subsequent values are in 1997 dollars.
[8] See U.S. Environmental Protection Agency (1998b, p. 30313).
[9] They use estimates of the effect of blood lead on IQ from Schwartz (1994) and estimates of the effect of IQ on lifetime earnings from Salkever (1995). Salkever's work updates earlier work by Griliches (1977).
[10] See U.S. Environmental Protection Agency (1998a, p. 3-13).
[11] See U.S. Environmental Protection Agency (1998a, Chapter 5).
[12] See Needleman, et al. (1979, 689). See also Greene and Ernhart (1993).

Agee and Crocker in 1996 developed an approach that avoids the shortcomings of the federal agencies' estimates.[13] They estimate parental willingness to pay to reduce lead in children's bodies by modeling parental demand for chelation, a medical treatment that reduces body lead burden. Agee and Crocker use data on lead in children's teeth, and so avoid any reliance on blood-lead levels.

No one has compared the 1996 estimates of Agee and Crocker with those currently used by EPA and HUD. EPA's 1998 analysis of the costs and benefits of its proposed lead hazard standards does not discuss the earlier research of Agee and Crocker.[14] Similarly, the benefit-cost analysis completed by HUD in support of its 1999 regulation contains no mention of Agee and Crocker.[15]

I show here that the estimates of parental willingness to pay developed by Agee and Crocker are roughly one sixth of the benefits estimates used by regulatory agencies. Hazard standards that protect children far more than their parents think is appropriate may make little sense. The agencies should consider relaxing their lead standards.

In the next section, I translate the Agee and Crocker estimates into dollars per unit change in IQ—a value that can be compared with the formulations used by regulatory agencies. I then assess causes of the difference in the estimates. Finally I discuss implications of these estimates for federal efforts to establish lead hazard standards in housing and make recommendations to policy-makers.

2. Benefits from Chelation Versus Agency Estimates

Agee and Crocker derive estimates of the value of reducing lead in children by studying parental decisions to use chelation therapy, a medical procedure that accelerates the natural excretion of lead from children's bodies. Chelation is not recommended for children with blood-lead levels below 20 Wg/dl,[16] an amount twice a level of concern identified by the Centers for Disease Control.[17] Agee and Crocker report that parental decisions to use chelation therapy imply an average willingness to pay for a 1 percent reduction of child lead body burden of $31 for parents on average or about $210 for a

[13] See Agee and Crocker (1994), (1996a), and (1996b).
[14] See U.S. Environmental Protection Agency (1998a).
[15] See U.S. Department of Housing and Urban Development (1999a).
[16] See American Academy of Pediatrics (1995).

reduction in lead in teeth of one part per million.[18] Their estimates for the relatively few families that chose to chelate were about six times greater. Agee and Crocker's key equation for the derivation of the marginal estimates is

$$(1) \qquad MWTP_l = (\pi_M / \lambda)(\partial V_M / \partial l)$$

Equation (1) relates the marginal willingness to pay for reductions in lead, $MWTP_l$, to the probability of obtaining chelation therapy, $\_{M}$, the marginal utility of income, U, and the marginal effect of reducing dentine lead, *l*, on the maximum attainable expected utility level if chelation therapy is chosen, V_M.

In developing this equation, Agee and Crocker assume that utility, U=U(X,R), is a function of X, commodities consumed that are not specific to the child's health, and also R, a measure of the expected severity of the child's ill health. In addition, R(A,M; *l*,E), where A represents exposure reduction, M is medical treatment, and E represents family characteristics that may influence risk. If R is interpreted as the IQ deficit attributable to lead, then it is straightforward to extend Agee and Crocker's research in a manner that allows comparability with other methods of valuing reductions in lead exposure. In particular, multiplying (1) by (jℓ/jIQ) gives the willingness to pay for an IQ improvement from reduced lead burdens

$$(2) \qquad MWTP_{IQ} \equiv (MWTP_l)\,(\partial l / \partial IQ) = (\pi_M / \lambda)(\partial V_M / \partial l)(\partial l / \partial IQ)$$

Several researchers report a correlation between dentine lead levels—the focus of Agee and Crocker—and measures of behavior and cognitive ability.[19] Needleman et al. report a difference in mean full-scale IQ of 4.5 points between low lead and high lead groups.[20] Children classified as low lead had dentine lead levels less than 10 ppm, (approximately the 40th percentile), while high lead children had dentine lead levels greater than 20 ppm (approximately the 80th percentile).[21] Figure 1 in Needleman *et al.* suggests that the mean dentine lead levels for the low and high lead groups are about 6

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[17] See U.S. Centers for Disease Control (1997b).
[18] I derive the estimate of $210 by multiplying the Agee and Crocker estimate of $16.11 (1996a, Table 3) by an inflation adjustment to convert to 1997 dollars and dividing by 0.15, 1 percent of the average dentine lead level observed in their sample (1996a, Table 1).
[19] See Needleman, et al. (1979), Needleman et al. (1990), and Greene and Ernhart (1993).
[20] See Needleman, et al. (1979, Table 7).
[21] See Needleman, et al. (1979, p. 690).

ppm and 33 ppm respectively. Since the low lead group has an average IQ about 4.5 points greater than the IQ for the high lead group, the change in IQ expected for a unit change in dentine lead is about 0.17.[22] Schwartz reports an effect of 0.19 based on a reassessment of the Needleman et al. work.[23] Therefore,

$$(3) \qquad \Delta IQ / \Delta l \quad \approx \quad 0.19$$

Substituting (3) into (2) and ignoring any difference between discrete and infinitesimal changes implies

$$(4) \qquad MWTP_{IQ} \approx \; (MWTP_l)(\frac{1}{.19}) = \$1{,}100$$

where $MWTP_l$ is Agee and Crocker's estimate of the mean willingness to pay for an IQ gain of one point ($210).

The relationship between blood lead and dentine lead provides a second way to compare the Agee and Crocker estimates with those of the regulatory agencies. Equation (1) implies

$$(5)\, MWTP_{IQ} \equiv MWTP_l \; (\partial l / \partial L_B)(\partial L_B / \partial IQ) = (\pi_M \; / \lambda)(\partial V_M / \partial l)(\partial l / \partial L_B)(\partial L_B / \partial IQ)$$

To implement (5) requires information about $\partial IQ/\partial L_B$, the effect of blood lead on IQ. Schwartz states the data suggest "an average decrease of about 0.25 IQ points per µg/dl" of lead in blood, a relationship used by EPA.[24] Thus, for these young children,

$$(6) \qquad \partial L_B / \partial IQ = 1/0.25$$

Implementation of (5) also requires information about $\partial l / \partial L_B$, the effect of blood-lead levels on dentine lead levels. This may vary with the time profile of the exposure to lead.[25] Needleman et al. report that twenty-three subjects with high dentine lead (>20 ppm) had a mean blood-lead level of 35.5 ?10.1 µg/dL, four to five years before shedding teeth. In addition, fifty-eight subjects with low dentine lead (<10ppm) had a mean blood-lead level of 23.8?6.0 µg/dL, four to five years before shedding teeth.[26] Assuming again that the mean of the low dentine lead levels is 6 ppm and the mean of the

[22] See Needleman, et al. (1979, Figure 1).
[23] See Schwartz (1993, p. 242).
[24] See Schwartz (1993, p. 244).
[25] See Rust, et al. (1999).
[26] See Needleman, et al. (1979).

high dentine lead levels is 33 ppm, the relationship between dentine lead and blood lead is

(7) $\Delta l \;/\, \Delta L_B \;=\; (27\, ppm) \,/\, (11.7 \mu g \,/\, dL) \;=\; 2.3$

Substituting equations (6) and (7) into (5) and using Agee and Crocker's estimate that $MWTP_l$=\$200, implies that $MWTP_{IQ}$ is about \$1,900. This value is more than the \$1,100 estimate implied by the first method but still much lower than implied by the methods used by HUD and EPA. While these estimates are clearly uncertain, their derivation does not permit the easy construction of confidence limits. It is not clear whether they are more uncertain than the estimates by the regulatory agencies, which are sensitive to assumptions about discount rates and wages forty years in the future.

3. Interpretations

When converted into estimates of willingness to pay for IQ improvements from reductions in lead burdens, the estimates implicit in Agee and Crocker are much smaller than the estimates based on the expected present value of changes in future earnings. The earnings-based estimates are about \$8,800 per IQ point, given the agencies' preferred 3 percent discount rate.[27] The midpoint of the estimates I derive from Agee and Crocker is about one sixth of the estimate preferred by EPA. The gap between these two estimates warrants an examination of its causes and its implications for policy.

Explaining the Difference

What is the source of the six-fold difference between these two estimates? First the lower estimates measure benefits to *parents* while the higher estimates developed by regulatory agencies purport to measure benefits to *children*. These benefits may differ because:

- Discount rates implicit in parental decisions exceed the 3 percent rates that HUD and EPA use to discount future labor income. In fact, Agee and Crocker report that the average discount rate implicit in the parental chelation decisions is about 4.7 percent.[28] They report that better-off and well-educated parents exhibit discount rates that approximate the real market rate for financial instruments;

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[27] See U.S. Environmental Protection Agency (1998a).
[28] See Agee and Crocker (1996b).

while worse-off and ill-educated parents exhibit rates roughly twice the market rate.

- Parents perceive that the growth in wages during their children's life is likely to be lower than the 1 percent per year assumed by the regulatory agencies. Lower wages imply lower absolute returns to IQ, according to the agencies' estimation methods.
- Parental altruism towards their children is incomplete, in that parents may value children's welfare less than their own, and parents decline to finance worthwhile investments in their children's human capital because their children can not offer credible commitments to repay such investments.

It is unclear how much of the gap in the estimates might be explained by these factors.

Second, the sample used by Agee and Crocker may not be representative of the population that the federal agencies presumably try to model. The Agee and Crocker sample appears less educated than average U.S. adults with young children during the same period. The fathers had only 11.9 years of schooling while the mothers had 11.6 years; over 80 percent of Americans of the relevant age group have graduated from high school.[29] In addition, Agee and Crocker report parents' annual *wage* income of $17,200 (in 1980 dollars), an amount slightly below the mean annual household *money* income of U.S. residents, which was $18,800 (in 1980 dollars).[30] But the population affected by the HUD and EPA regulations may also be poorer than the U.S. population. Thus the extent to which the Agee and Crocker data set is unrepresentative of the populations affected by the HUD and EPA analyses is unclear.

Third, the estimates I derive from Agee and Crocker use a relationship between IQ and dentine lead that is different from the IQ-blood lead relationship underlying the government's estimates of benefits. Although there is little basis for assessing how much if any of the gap between the two sets of estimates may be due to this difference in estimation methods, dentine lead is likely to be a better predictor of IQ. Blood lead can return to normal levels even when exposure to lead has been excessive.[31]

[29] See U.S. Department of Education (1998).
[30] See U.S. Department of Commerce (1995).
[31] See Needleman, et al. (1979).

The difference between the two sets of estimates suggests that substantially more research is needed to improve the application of benefit-cost analysis to problems of children's environmental health. Risks from lead have been the subject of academic studies for decades, as illustrated by the meta-analysis by Lanphear et al. of twelve previous epidemiological studies.[32] Estimates of the value of reductions in lead need greater precision to help government agencies make sound decisions. There is substantial new work on the value of improving children's health generally,[33] but given the potential costs of abating residential lead, more research on the value of reducing lead levels in children is needed.

Implications of the Difference

Is one set of estimates better than the other for benefit-cost analyses? The lower estimates have obvious strengths—they are based on revealed preferences and avoid the use of blood lead. These strengths should prompt a reexamination of the methods underlying the agencies' estimates of benefits to children. More broadly, however, the lower benefits estimates are different because they represent benefits to *parents*.

The gap between parental and children's benefits from controlling lead hazards indicates that mandatory controls, if financed by parents, would transfer significant resources from parents to their own children. Residential hazard standards proposed by EPA would cost about $58 billion in present value.[34] In owner-occupied housing, where most violations of EPA's residential hazard standards would occur, parents would pay all of the costs of controlling lead. In rental housing, landlords would pay a share of the costs. EPA estimates that the benefits to children of its proposed standards would be between $44 and $170 billion in present value. Since the benefits to parents would be about one sixth as much, compliance with EPA's standards would redistribute substantial resources from parents to children.

This resource transfer is inequitable because the children are better off than their parents. Overall life expectancy at birth is about six years greater than it was thirty years ago; for black males, life expectancy has grown 4.6 years over this interval.[35] Income is

[32] See Lanphear, et al. (1998).
[33] See, for example, Jenkins et al. (2000) and Schulze et al. (2000).
[34] See U.S. Environmental Protection Agency (1998a, p. ES-2).
[35] See U.S. Department of Commerce (1999, Table 127).

also projected to grow substantially over the next forty years. In deriving its estimate of $8,800 in income gains per additional IQ point, EPA assumed that real wages grow at 1 percent per year throughout the life of the children.[36] This rate of increase implies that the children at age thirty will have earnings about 35 percent higher than they would if they were working today. By age forty the gain would be 50 percent. Lead-related IQ losses reduce this difference only very slightly. The average child's IQ loss from lead exposure is one point.[37] A loss of one IQ point would lower lifetime earnings by about 2.4 percent, according to EPA.[38]

This intergenerational transfer is fundamentally different from others that have occupied the attention of economists and policy-makers. Unlike the future generations that might benefit from controls on global warming and nuclear waste disposal, the children who would benefit from reduced lead hazards are living in the care of their parents, and their parents have control of such hazards.

In addition, this transfer matters because parents control family resources. Regulations that impose net costs on parents will likely reduce voluntary private investment in children, at least to the extent that such investment is a normal good. In this sense regulatory efforts to improve children's health, like a leaky bucket, may deliver benefits to the intended beneficiaries that are smaller than anticipated.

My analysis, like the work by the regulatory agencies, has not pursued a broader thesis of Agee and Crocker's research: the joint determination of children's human capital by both parental investments and the environment. Joint determination suggests that estimates of the effects of one factor derived without disentangling it from the other may lead to misleading results. For example, Agee and Crocker show that parents who discount the future only slightly have children with relatively high IQ.[39] Their findings suggest that parental support for programs to remediate lead is likely to be more modest among parents of low IQ children—that is, the most needy children.

[36] See U.S. Environmental Protection Agency (1998a, p. 5-7).
[37] See U.S. Environmental Protection Agency (1998c, p. ES-4).
[38] See U.S. Environmental Protection Agency (1998a, p. 5-10).
[39] See Agee and Crocker (1999).

4. Conclusions

Based on Agee and Crocker's research, I derive estimates of the benefits to parents of reducing children's lead levels that are about one-sixth the estimates of benefits used by HUD and EPA. These estimates use preferences revealed by parental decisions and measures of lead body burdens that reflect exposure to lead more accurately than the blood-lead data used by regulatory agencies. They raise questions about the reliability of the much larger benefits estimates used by the regulatory agencies.

These estimates, when applied to EPA's estimates of costs and benefits of its proposed lead hazard standards, indicate that the costs to parents would be between $26 billion and $46 billion greater than the benefits, in present value terms. Put differently, EPA's proposed standards, if mandatory, would impose costs on parents that are between two and seven times larger than the benefits to parents.

Federal regulatory agencies should reconsider their lead hazard standards. The standards redistribute family resources from parents to children. But such redistribution is inequitable because children are likely to live longer and have much higher incomes than their parents. The government should reconsider the need for environmental standards that protect children more than their parents think is appropriate.

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