Association of Childhood Blood Lead Levels With Criminal Offending

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IMPORTANCE Lead is a neurotoxin with well-documented effects on health. Research suggests that lead may be associated with criminal behavior. This association is difficult to disentangle from low socioeconomic status, a factor in both lead exposure and criminal offending.

OBJECTIVE To test the hypothesis that a higher childhood blood lead level (BLL) is associated with greater risk of criminal conviction, recidivism (repeat conviction), conviction for violent offenses, and variety of self-reported criminal offending in a setting where BLL was not associated with low socioeconomic status.

DESIGN, SETTING, AND PARTICIPANTS A total of 553 individuals participated in a prospective study based on a population-representative cohort born between April 1, 1972, and March 31, 1973, from New Zealand; the Dunedin Multidisciplinary Health and Development Study observed participants to age 38 years (December 2012). Statistical analysis was performed from November 10, 2016, to September 5, 2017.

EXPOSURES Blood lead level measured at age 11 years.

MAIN OUTCOMES AND MEASURES Official criminal conviction cumulative to age 38 years (data collected in 2013), single conviction or recidivism, conviction for nonviolent or violent crime, and self-reported variety of crime types at ages 15, 18, 21, 26, 32, and 38 years.

RESULTS Participants included 553 individuals (255 female and 298 male participants) who had their blood tested for lead at age 11 years. The mean (SD) BLL at age 11 years was 11.01 (4.62) μg/dL. A total of 154 participants (27.8%) had a criminal conviction, 86 (15.6%) had recidivated, and 53 (9.6%) had a violent offense conviction. Variety scores for self-reported offending ranged from 0 to 10 offense types at each assessment; higher numbers indicated greater crime involvement. Self-reported offending followed the well-established age-crime curve (ie, the mean [SD] variety of self-reported offending increased from 1.99 [2.82] at age 15 years to its peak of 4.24 [3.15] at age 18 years and 4.22 [3.02] at age 21 years and declined thereafter to 1.10 [1.59] at age 38 years). Blood lead level was a poor discriminator between no conviction and conviction (area under the curve, 0.58). Overall, associations between BLL and conviction outcomes were weak. The estimated effect of BLL was lower for recidivism than for single convictions and lower for violent offending than for nonviolent offending. Sex-adjusted associations between BLL reached statistical significance for only 1 of the 6 self-reported offending outcomes at age 15 years (r = 0.10; 95% CI, 0.01-0.18; P = .02).

CONCLUSIONS AND RELEVANCE This study overcomes past limitations of studies of BLL and crime by studying the association in a place and time where the correlation was not confounded by childhood socioeconomic status. Findings failed to support a dose-response association between BLL and consequential criminal offending.

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Recent discoveries of elevated lead levels in the drinking water of several US cities have prompted researchers to reexamine the long-term effects of lead exposure.[1-4] Childhood lead exposure has been associated with abnormalities in brain structures, such as the hippocampus and cerebral cortex, and with disrupted neuronal development, myelination, and neurochemical processing.[5-7] Lead exposure has also been associated with childhood behavioral problems and lasting declines in intelligence.[8-10] One hypothesized behavioral effect of high levels of lead exposure is increased antisocial and criminal behavior.[11] Criminal offending carries consequences for offenders' life outcomes, including employment, family life, and life expectancy.[12-14] Research has found that individuals with elevated childhood blood lead levels (BLLs) show increased criminal offending throughout adulthood.[15-19] Aggregate-level research has also linked estimated exposure to environmental lead with higher rates of crime.[20-27] One of the most intriguing propositions is that declines in US children's BLLs, which began in the 1970s as lead was gradually removed from the environment, contributed to lower rates of crime across the United States as the children became adolescents during the mid-1990s.[11,28,29]

Some findings, however, indicate that past studies may have yielded inaccurate estimations of the true associations between lead and health and behavioral outcomes owing to confounding by low socioeconomic status.[30,31] New Zealand's Dunedin Multidisciplinary Health and Development Study (Dunedin Study) offers the opportunity to study the effects of lead in the body on crime, independent of socioeconomic status. In the Dunedin Study, as previously reported, childhood BLLs were representative of the BLLs of New Zealand children and were not associated with childhood socioeconomic status.[9,32,33] New Zealand has a reputation as a "green" (environmentally friendly) country, but during the Dunedin Study cohort's childhood in the 1970s and 1980s, there was evidence of the association between leaded gasoline and elevated BLLs.[34] The BLL measure used in this article has provided evidence, in the Dunedin cohort, of associations between higher childhood BLL and lower midlife IQ and higher childhood BLL and socioeconomic attainment.[9] This study tested the hypothesis that BLL is positively associated with crime.

In addition to testing whether BLL is associated with criminal conviction, this study tested 3 additional hypotheses about crime. First, based on results of past research,[19] we tested the hypothesis that BLL is associated with a greater likelihood of recidivistic vs one-time criminal conviction. Many people who experience a criminal conviction never recidivate (have a repeat conviction from a new court case); some, however, do recidivate.[35] Recidivating offenders may be etiologically different from one-time offenders and are a concern of the criminal justice system.[36,37] Second, research has also found a specific link between lead and violence,[27,38] leading us to test the hypothesis that BLL is associated with a greater likelihood of conviction for violent vs nonviolent offenses. Third, we tested the hypothesis that higher BLL is associated with more self-reported offending (ie, offenses committed as reported by a respondent, regardless of criminal conviction). It is well

Key Points

Question Is childhood lead exposure associated with criminal offending in a setting where the degree of lead exposure was not confounded by socioeconomic status?

Findings In this cohort study of 553 New Zealanders observed for 38 years, lead exposure in childhood was weakly associated with official criminal conviction and self-reported offending from ages 15 to 38 years. Lead exposure was not associated with the consequential offending outcomes of a greater variety of offenses, conviction, recidivism, or violence.

Meaning Responses toward lead exposure should focus on consequences for health, not potential consequences for crime.

established that more self-reported offending is associated with increased risk of criminal conviction, but most offenses go undetected.[39] Self-reports of offending may provide a more complete picture of the social burden imposed by an individual's offending whether or not it resulted in an official record.

Methods

Sample

Participants were members of the Dunedin Multidisciplinary Health and Development Study, a longitudinal investigation of health and behavior. The full cohort (1037 of 1139 [91.0% of eligible births]; 535 male [51.6%]) included all of the individuals born between April 1, 1972, and March 31, 1973, in Dunedin, New Zealand, who were eligible based on residence in the province and who participated in the first assessment at age 3 years. The cohort represented the full range of socioeconomic status in the general population of New Zealand's South Island.[40] On adult health, the cohort matches the New Zealand National Health and Nutrition Survey on key health indicators (eg, body mass index, smoking, and physician visits).[40] The cohort is primarily white, matching the demographics of the South Island.[40] Assessments were carried out at birth and ages 3, 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, and 38 years, when 961 of the 1007 participants who were still alive (95.4%) took part. Written informed consent was obtained from participants, and ethical approval for each assessment phase was obtained from the Otago Research Ethics Committee.

Blood Lead Level

Approximately 30 mL of venous blood was collected from each 11-year-old child who participated in the assessment (carried out at the Research Unit) and who freely agreed to give blood; 579 of the 803 children (72.1%) in attendance agreed to give blood. An additional 122 children, aged 11 years and tending to live outside city limits, were assessed in their schools, where blood could not be drawn. Whole-blood samples were analyzed through graphite furnace atomic absorption spectrophotometry. Blood lead level is reported in micrograms per deciliter (to convert to micromoles per liter, multiply by 0.0483). Details on the method of blood collection, division,

storage, and quality assurance and analysis procedures have been described previously.[32,33,41]

Criminal Offending

Official conviction records were obtained through a search of the central computer system of the New Zealand police, which provides details of all New Zealand convictions and Australian convictions communicated to the New Zealand police. Searches for all convictions occurring from the age from which conviction was permissible (14 years) were conducted after each assessment at ages 21, 26, 32, and 38 years (search completed in 2013). Conviction was coded as 1 for convicted participants and as 0 for unconvicted participants. Subgroups were one-time offenders vs those who recidivated and participants convicted only of nonviolent crime vs those convicted of a violent crime.

A self-reported offending interview was administered at ages 15, 18, 21, 26, 32, and 38 years using a 1-year retrospective window at each wave. Four types of offenses were assessed. Property offenses included items such as vandalism, breaking and entering, motor vehicle theft, embezzlement, shoplifting, and fraud. Rule offenses included items such as reckless driving, public drunkenness, soliciting or selling sex, giving false information on a loan or job application, and disobeying court orders. Drug-related offenses included using and selling various types of illicit drugs. Violent offenses included items about simple and aggravated assault, gang fighting, robbery, arson, and forced sex. We used offense items to create a variety score of self-reported offending. Variety scores are calculated by summing 1 point for a "yes" response to each different offense. Variety scores typically correlate with frequency,[42] but the variety score is preferred over frequency because variety is less skewed, does not overweight trivial offenses, and is less affected by recall errors (eg, "Have you shoplifted?" is more accurately recalled than "How many times have you shoplifted?").[43,44] The variety scores ranged from 0 to 30 offense types; higher numbers indicated greater crime involvement. To eliminate potential null findings owing to skew in self-reported offending, we winsorized self-reported offending variety scores at 10, which is the 90th percentile or higher self-reported offending variety score for each age. Results using the full variety scales did not substantively differ from results using the winsorized scales (eTable 1 in the Supplement). Self-reported offending across interviews at ages 15, 18, 21, 26, 32, and 38 years followed the universal age-crime curve[36,45]; that is, the mean (SD) variety of self-reported offending increased from 1.99 (2.82) at age 15 years to its peak of 4.24 (3.15) at age 18 years and 4.22 (3.02) at age 21 years and declined thereafter to 1.10 (1.59) at age 38 years (**Table**).

Potential Confounders

Analyses were adjusted for sex. As in prior studies, boys in the cohort had more criminal offending and slightly higher childhood BLLs than did girls (**Figure 1**).[9,44,46] Control for sex was indicated because a male excess of both BLLs and offending could yield spurious associations in the cohort. In addition, higher BLLs and higher rates of crime are usually more likely to be found among children who come from families with low socioeconomic status.[30,45] However, we report in Figure 1[46] the null association between childhood socioeconomic status and BLLs in this cohort (this null association was previously reported for the subsample of the Dunedin Study having IQ data[9]).

Statistical Analysis

Statistical analysis was performed from November 10, 2016, to September 5, 2017. The analytic sample for this study was 553 participants. Starting with the 579 participants with BLL data at age 11 years, we excluded 26 individuals who did not consent to criminal record searching or did not survive to the age at which we first obtained consent for searches (21 years). To test whether the participants who were tested for lead were representative of the untested cohort who met inclusion criteria, we compared the analytic sample of 553 with the subsample of 414 without BLL data. Participants who were tested for lead did not differ significantly from untested children on official criminal conviction, self-reported offending, sex, or childhood socioeconomic status. Because rural children tended to be seen at their schools at age 11 years (where lead could not be tested), more children tested for lead lived in town, and the children tested for lead had a 2-points-higher childhood IQ (eTable 2 in the Supplement).

Study members with BLLs higher than 23 μg/dL (n = 10) were referred for medical evaluation, following the recommended clinical protocol at that time, and may have been treated.[41] We have retained these study members in our analysis as their removal did not substantively alter results.

We calculated descriptive statistics for the complete analytic sample and also by BLL (in approximately 5-μg/dL groups). We analyzed the accuracy of BLLs to discriminate between no conviction and conviction using receiver operating characteristic curves and area under the curve (AUC). As a comparison, we included the receiver operating characteristic curve and AUC for male sex and a model that combined male sex and BLL. The receiver operating characteristic curve plots the estimated true-positive (sensitivity) and false-positive (1 − specificity) rates for conviction. The AUC is an indicator of accuracy. An AUC value of 0.5 indicates that model variables are no better at estimating the outcome than random chance. An AUC value of 1 indicates that model variables perfectly estimate the outcome.

We tested the associations between childhood BLLs and measures of offending using regression models (Table). Using logistic regression models, we estimated the odds ratio (OR) of criminal conviction by BLL. Using multinomial logistic regression models, we estimated the OR of being a one-time offender or recidivating vs being a nonoffender by BLL and the OR of being a nonviolent offender or a violent offender vs being a nonoffender by BLL. Blood lead level was analyzed as a continuous measure; however, it is presented in 5-μg/dL units in the Table, the current reference level for clinical attention and therefore a measure that is meaningful to clinicians and policymakers. Moreover, 5 μg/dL represents approximately 1 SD of BLL in the cohort. We estimated the amount of self-reported offending at each assessment age by BLL using ordinary least squares regression. For self-reported offending, all

Table. Descriptive Statistics of Study Variables and Associations of BLL With Offending Outcomes[a]

| Measure | Descriptive Statistics (N = 553) | Descriptive Statistics by BLL Category | | | | Association With BLL (95% CI)[b] | | | |
		≤5 µg/dL (n = 33)	6-10 µg/dL (n = 265)	11-15 µg/dL (n = 173)	>15 µg/dL (n = 82)	Unadjusted	P Value	Adjusted for Male Sex[c]	P Value
Childhood BLL, mean (SD), µg/dL	11.01 (4.62)	NA	NA	NA	NA	NA	NA	NA	NA
Criminal conviction, No. (%)									
No	399 (72.2)	25 (75.8)	204 (77.0)	112 (64.7)	58 (70.7)	1 [Reference]	NA	1 [Reference]	NA
Yes	154 (27.8)	8 (24.2)	61 (23.0)	61 (35.3)	24 (29.3)	1.29 (1.06-1.56)	.01[d]	1.23 (1.00-1.51)	.05
Conviction subgroup comparison 1, No. (%)									
One-time offender	68 (12.3)	2 (6.1)	29 (10.9)	26 (15.0)	11 (13.4)	1.29 (0.99-1.68)	.06	1.25 (0.95-1.64)	.11
Recidivistic offender	86 (15.6)	6 (18.2)	32 (12.1)	35 (20.2)	13 (15.9)	1.28 (1.01-1.63)	.046[d]	1.21 (0.93-1.57)	.15
Conviction subgroup comparison 2, No. (%)									
Nonviolent offender	101 (18.3)	5 (15.2)	40 (15.1)	38 (22.0)	18 (22.0)	1.33 (1.06-1.67)	.01[d]	1.28 (1.01-1.61)	.04[d]
Violent offender	53 (9.6)	3 (9.1)	21 (7.9)	23 (13.3)	6 (7.3)	1.20 (0.89-1.62)	.24	1.13 (0.82-1.55)	.45
Self-reported offending variety, mean (SD), No.									
Age 15 y	1.99 (2.82)	1.39 (2.34)	1.79 (2.77)	2.17 (2.83)	2.49 (3.04)	0.10 (0.02-0.19)	.02[d]	0.10 (0.01-0.18)	.02[d]
Age 18 y	4.24 (3.15)	3.25 (2.69)	4.06 (3.02)	4.54 (3.33)	4.64 (3.25)	0.09 (0.00-0.17)	.04[d]	0.06 (−0.02 to 0.14)	.16
Age 21 y	4.22 (3.02)	3.82 (2.51)	4.15 (2.92)	4.30 (3.21)	4.49 (3.15)	0.04 (−0.04 to 0.13)	.30	0.01 (−0.06 to 0.09)	.75
Age 26 y	2.83 (2.55)	2.03 (1.49)	2.58 (2.40)	3.27 (2.74)	3.01 (2.78)	0.09 (0.01-0.17)	.03[d]	0.06 (−0.02 to 0.13)	.15
Age 32 y	2.25 (2.19)	1.50 (1.83)	2.03 (1.83)	2.80 (2.54)	2.08 (2.37)	0.08 (−0.01 to 0.16)	.08	0.04 (−0.04 to 0.12)	.28
Age 38 y	1.10 (1.59)	0.74 (0.73)	1.01 (1.49)	1.36 (1.88)	0.99 (1.44)	0.04 (0.04-0.12)	.32	0.02 (−0.06 to 0.10)	.66
Sex, No. (%)									
Female	255 (46.1)	17 (51.5)	137 (51.7)	68 (39.3)	33 (40.2)	1 [Reference]	NA	NA	NA
Male	298 (53.9)	16 (48.5)	128 (48.3)	105 (60.7)	49 (59.8)	0.10 (0.02-0.18)	.02[d]	NA	NA

Abbreviations: BLL, blood lead level; NA, not applicable.

SI conversion factor: To convert lead to micromoles per liter, multiply by 0.0483.

[a] Full sample, N = 553. Age 15 years, n = 543; age 18 years, n = 535; age 21 years, n = 541; age 26 years, n = 543; age 32 years, n = 542; and age 38 years, n = 540.

[b] For conviction, odds ratio from logistic regression of conviction on BLL in 5-µg/dL units; reference category is no conviction. For conviction subgroups,

odds ratios from multinomial logistic regression models of subgroup on BLL in 5-µg/dL units; reference category is no conviction. For variety of self-reported offenses, standardized β coefficients reported for offending variety regressed on BLL; these estimates can be interpreted as correlation coefficients (r).

[c] Model fit was significantly improved by adjusting for all but variety of self-reported offenses at 15 years of age.

[d] P < .05.

model variables were standardized so that the results could be interpreted as correlation coefficients (r). All models were adjusted for the effect of sex; adjusted and unadjusted results are presented in the Table. Model fit statistics and tests of model fit contrasting adjusted with unadjusted models are in eTable 3 in the Supplement.

In sensitivity analyses, we subjected the BLL measure to a logarithmic transformation and a correction for hematocrit levels[47]; the results did not differ substantively from the results reported here (eTable 4 in the Supplement). Statistical analyses were conducted in R, version 3.4.0 (R Foundation for Statistical Computing) using the nnet[48] and pROC[49] packages.

Results

Childhood BLLs ranged from 4.00 to 31.00 µg/dL, with a mean (SD) BLL of 11.01 (4.62) µg/dL (Table). There was no significant socioeconomic gradient in lead exposure in the cohort children (r < −0.001; 95% CI, −0.08 to 0.08; P = .99). High BLLs were observed among children from all socioeconomic status

groups (Figure 1).[46] A total of 154 participants (27.8%) had a criminal conviction, 68 (12.3%) were one-time offenders, 86 (15.6%) had recidivated, 101 (18.3%) were nonviolent offenders, and 53 (9.6%) were violent offenders.

Criminal conviction was more prevalent and more frequent at higher BLLs: 8 of 33 participants (24.2%) with a BLL of 5 µg/dL or less had a criminal conviction compared with 24 of 82 participants (29.3%) with a BLL above 15 µg/dL (Table). The receiver operating characteristic curve AUC (Figure 2), however, showed that BLL alone poorly discriminated between no conviction and conviction. That is, at no point or threshold was BLL capable of distinguishing no conviction from conviction with dependable accuracy. The accuracy of male sex exceeded that of BLL, and BLL contributed a minimal increase in accuracy beyond that of male sex.

Logistic regression models supported the positive association between BLL and conviction, but sex-adjusted results failed to reach statistical significance (Table). Specifically, each 5-µg/dL higher BLL was significantly associated with a 1.29 increase in the odds of criminal conviction (95% CI, 1.06-1.56; P = .01). After controlling for sex, the association between BLL

Figure 1. Distribution of Blood Lead Levels
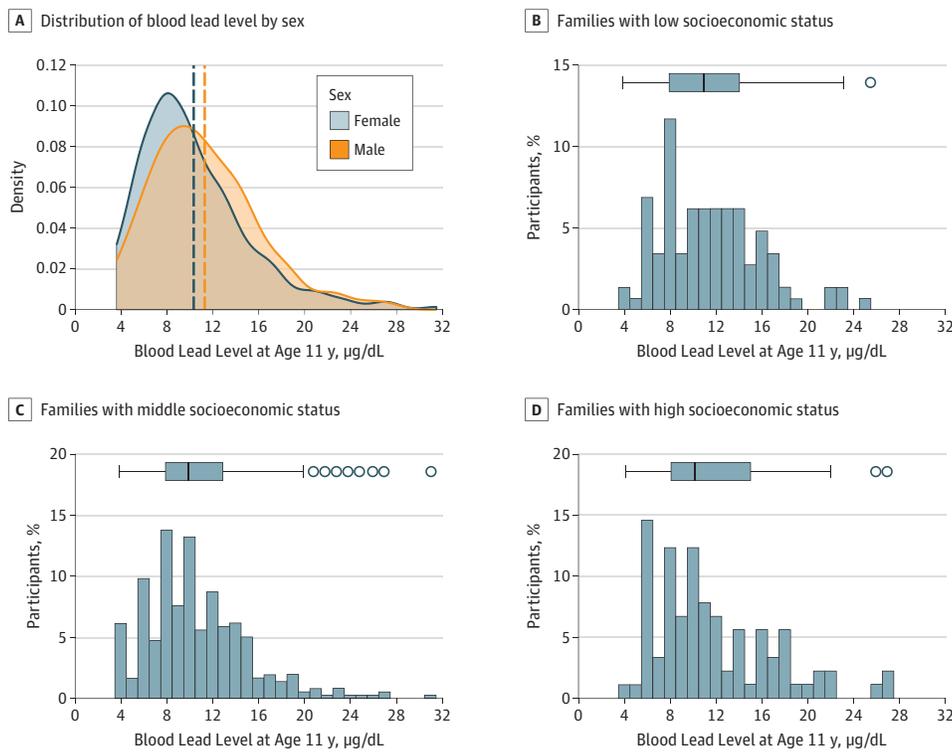
A, Distribution of blood lead levels by sex (553 participants). Mean blood lead level is lower for female participants (10.51 μg/dL [to convert to micromoles per liter, multiply by 0.0483]) compared with male participants (11.44 μg/dL; P = .02). B, A total of 109 participants from families with low socioeconomic status. C, A total of 1355 participants from families with middle socioeconomic status. D, A total of 189 participants from families with high socioeconomic status. Low, middle, and high socioeconomic statuses are based on the 6-point Elley-Irving scale[46] (categories 1 and 2 [low status], 3 and 4 [middle status], and 5 and 6 [high status]), which codes the occupations of the study members' parents and their associated income and educational levels. There was no significant socioeconomic gradient in lead exposure in the cohort children (r < −0.001; 95% CI, −0.08 to 0.08; P = .99). High blood lead levels were observed in all status groups. The box and whisker plots show the median (vertical black line inside the box), lower and upper interquartile ranges (IQRs; left and right borders of the box), lower-bound value equal to the 25th percentile minus 150% of the IQR and upper-bound value equal to the 75th percentile plus 150% of the IQR (whiskers), and outlier observations (circles). The histogram interval bins represent whole integers of blood lead level.

and conviction was slightly attenuated and not statistically significant (adjusted OR, 1.23; 95% CI, 1.00-1.51; P = .05).

Analysis of recidivism revealed that BLL was not significantly associated with the odds of recidivism (conviction subgroup comparison 1 in the Table). Blood lead level was not significantly associated with being a one-time offender (OR, 1.29; 95% CI, 0.99-1.68; P = .06; adjusted OR, 1.25; 95% CI, 0.95-1.64; P = .11). Initially, when comparing offenders who recidivated with nonoffenders, each 5-μg/dL-higher BLL was significantly associated with a 1.28 increase in the odds of being a recidivating offender (95% CI, 1.01-1.63; P = .046). However, after controlling for sex, the association between higher BLL and being a recidivating offender was slightly attenuated and not statistically significant (adjusted OR, 1.21; 95% CI, 0.93-1.57; P = .15). In each of the models, the estimated OR was slightly lower for being a recidivating offender than for being a one-time offender.

Analysis of violence revealed that BLL was not significantly associated with conviction for violence (conviction subgroup comparison 2 in the Table), although it was associated with conviction for nonviolent offenses. Comparing nonviolent offenders with nonoffenders, each 5-μg/dL-higher BLL was significantly associated with a 1.33 increase in the odds of being a nonviolent offender (95% CI, 1.06-1.67; P = .01), and this association remained significant after controlling for sex (OR, 1.28; 95% CI, 1.01-1.61; P = .04). However, BLL was not significantly associated with being a violent offender, and the estimated OR was slightly lower than that for being a nonviolent offender (OR, 1.20; 95% CI, 0.89-1.62; P = .24; adjusted OR, 1.13; 95% CI, 0.82-1.55; P = .45).

The variety of self-reported offenses was weakly associated with BLL and only reached statistical significant at ages 15, 18, and 26 years (Table). After controlling for sex, the association between higher BLL and variety of self-reported offenses remained weak and was statistically significant only at assessment age 15 years (r = 0.10; 95% CI, 0.01-0.18; P = .02).

Discussion

This study is, to our knowledge, the only study to examine the association between childhood BLL and criminal offending in a cohort in which the association is not linked with social class. We found weak associations between BLL and criminal of-

Figure 2. Association of Blood Lead Level, Male Sex, and Blood Lead Level and Male Sex With Criminal Offenses
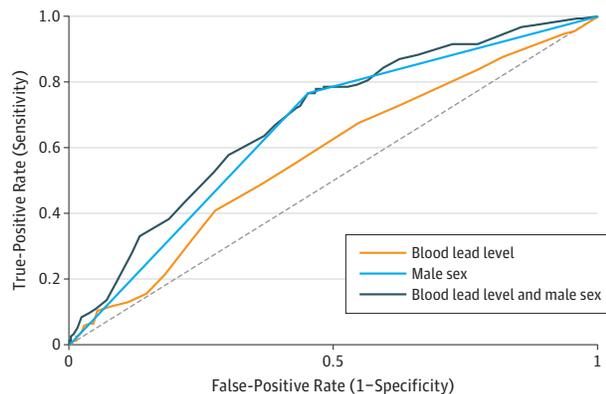
We assessed the ability of blood lead levels to discriminate between no conviction and conviction. The area under the curve (AUC) is an indicator of a model's accuracy. An AUC value of 0.5 (the diagonal line) indicates poor accuracy; that is, the model variables are no better at estimating the outcome than random chance. Points above the diagonal represent better-than-random accuracy at estimating the outcome. An AUC value of 1 indicates perfect accuracy. Blood lead level (AUC, 0.58) was a poorer discriminator between no conviction and conviction in the Dunedin cohort than was male sex (AUC, 0.66) and added little to the model beyond sex (AUC for blood lead level and male sex, 0.69).

fending. Blood lead level was associated with criminal conviction at chance levels and was outperformed by male sex. Contrary to expectations, the estimated effect of BLL was lower for recidivism than for 1-time conviction and lower for violent than nonviolent offending. Associations with self-reported offending were weak and, with the exception of age 15 years, not statistically significant. Our results failed to support a consistent dose-response association between BLL and criminal offending, measured through official reports and self-reports, from adolescence to adulthood. This finding does not negate the evidence of the detrimental health effects of lead. At-risk children should continue to be tested for lead, and efforts to reduce lead exposure should continue.

Our findings of a tenuous association between BLL and criminal offending run contrary to past research, which has shown a dose-response association between BLL and crime.[15-19] Our findings are unlikely owing to poor-quality measurement of BLL because past research from the Dunedin Study that used the same measure of BLL as used in the present study found that higher childhood BLL was associated with declines in intelligence test scores and downward social mobility at age 38 years.[9]

Our results may be owing to the absence of 3 factors found to be problematic in past studies indicating dose-response effects of BLL. First, past studies of the association

between BLL and crime, in which high BLL and low socio-economic status were associated, may not have completely overcome confounding.[30,31] Second, many past studies of the association between BLL and crime used high-risk or clinical samples, which meta-analysis has shown to yield higher effects of BLL on crime.[50] Third, past longitudinal studies of the association between BLL and crime have notable attrition, which may upwardly bias estimates if individuals with high BLL and low crime rates or individuals with low BLL and high crime rates disproportionately leave the sample.

Limitations

This study has limitations. First, BLL was measured at only 1 point, age 11 years. Multiple BLL measures are desirable. However, evidence indicates that the mean of BLL measurements across childhood can yield results similar to those from a single, later-childhood measurement, as used here.[51] Past research analyzing multiple BLL measures from early to middle childhood also found the strongest effects among BLL measurements most proximal to the outcome, as we found with self-reported offending at age 15 years.[52,53] Second, this study's findings may not generalize to nonwhite children. High BLLs are prevalent among children in many non-Western countries and in African American children in the United States.[54,55] There is currently no evidence to suggest that racial or ethnic groups differ on lead metabolism. In the United States specifically, the effects of lead may be amplified by the stress of racial disparity and discrimination or by malnutrition, which are often experienced by African American children.[5,56] Third, the study was also predominantly of children from nonrural areas. Mean BLL in the Dunedin Study, 11.01 μg/dL, was comparable with BLLs in other developed locations in the 1980s, but this BLL limits our ability to make inferences about the effects of lower BLLs seen in present-day US children.[54] Fourth, our crime outcomes were assessed at age 15 years and older; there is evidence that elevated BLLs are associated with childhood and preteen problem behaviors.[52,54]

Conclusions

This study fails to support a dose-response association between BLL and criminal offending in a sample in which there was no association between BLL and childhood socio-economic status. Previously detected associations between BLL and criminal offending may be owing to the toxic effect of lead disproportionately affecting disadvantaged groups. Responses toward lead exposure should focus on health consequences, not potential criminal consequences.

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