Pessimism, a general tendency toward negative expectancies, is a risk factor for depression and also heart disease, stroke, and reduced cancer survival. There is evidence that individuals with higher lead exposure have poorer health. However, low socioeconomic status (SES) is linked with higher lead levels and greater pessimism, and it is unclear whether lead influences psychological functioning independently of other social factors. The authors considered interrelations among childhood and adult SES, lead levels, and psychological functioning in data collected on 412 Boston area men between 1991 and 2002 in a subgroup of the VA Normative Aging Study. Pessimism was measured by using the Life Orientation Test. Cumulative (tibia) lead was measured by x-ray fluorescence. Structural equation modeling was used to quantify the relations as mediated by childhood and adult SES, controlling for age, health behaviors, and health status. An interquartile range increase in lead quartile was associated with a 0.37 increase in pessimism score ($P < 0.05$). Low childhood and adult SES were related to higher tibia lead levels, and both were also independently associated with higher pessimism. Lead maintained an independent association with pessimism even after childhood and adult SES were considered. Results demonstrate an interrelated role of lead burden and SES over the life course in relation to psychological functioning in older age.

**Abbreviations:** KXRF, K-shell x-ray fluorescence; RMSEA, root mean square error of approximation; SD, standard deviation; SES, socioeconomic status.

Exposures to environmental toxicants, poor physical health, and psychosocial functioning often cluster in lower socioeconomic status (SES) groups (1–5). Numerous investigators have posited that SES-related risks leading to health disparities may aggregate and accumulate throughout life to influence well-being and disease risk (1, 6, 7). Specifically considering psychosocial functioning, it has been postulated that growing up in lower SES environments may lead to impaired development of stress regulatory systems and also negatively bias the processing of psychosocial information both early and later in life (1). This does not rule out an independent effect of adult SES. These experiences are then hypothesized to link social disadvantage with impaired psychosocial functioning across the life course (6). However, whether exposure to environmental toxicants, which may be more prevalent in socially disadvantaged environments, leads to poor psychosocial functioning independently of other effects of social disadvantage has not been fully determined (8, 9).

Bone lead is a marker of cumulative lead exposure, because most lead absorbed by individuals is stored in bone rather than eliminated (10). The risk of lead exposure varies with SES, so that older adults who grew up in low SES conditions are more likely to have lived in lead-contaminated environments, including dilapidated housing and near areas of high-lead gasoline (5, 11–13). In addition, children in low SES environments are more likely to attain less education as adults,
have lower SES as adults, and live in residential areas and work in occupations with greater risk of lead exposure (2, 14). Researchers have found a link between lead and psychiatric symptoms in young adults and also in older men (15–17). For example, in the study population used for the present study, prior work found that tibia lead is associated with higher somatization and higher levels of general distress (15, 16). These studies controlled for adult SES by using educational attainment, which provides some reassurance that the relation between lead and poor psychological functioning is not an artifact. However, given the importance of early life environments in determining lead exposure and adult functioning (18), a stronger test of the relations would account for both childhood and adult SES.

Pessimism is a cognitive orientation (personality trait) characterized by generalized expectancy of negative outcomes (19, 20). It is associated with lower psychological well-being; for example, pessimism is a strong predictor of depressive symptomology even after accounting for other psychological factors (19). Pessimism has also been associated with a faster rate of cellular aging (21), as well as increased risk of chronic disease and premature mortality, the most compelling evidence of which has been related to cardiovascular disease (20, 22–26).

The current study expands upon earlier work by investigating the effect of cumulative lead on pessimism and the role of SES over the life course on the association between lead burden and pessimism. We hypothesized that cumulative lead would be related to increased pessimism, and that these effects would be maintained independently of childhood and adult SES. We further considered whether effects of childhood and adult SES on pessimism across the life course might be partly mediated by lead. As a secondary analysis, we investigated the relations among SES, tibia lead, and pessimism with a major mental disorder, depression, projected to globally be a leading cause of years of life with disability (27, 28). Given the known relation between pessimism and depression, we hypothesized that SES and lead would influence depression via pessimism.

**MATERIALS AND METHODS**

This study examined a subgroup of men in the VA Normative Aging Study, established in 1963 by the Veterans Administration (now the Department of Veterans Affairs). The cohort and subgroup of participants used in this research have been described elsewhere (29, 30). Briefly, the Normative Aging Study is a closed cohort of 2,280 male volunteers from the Greater Boston area. Men were screened at entry and enrolled if they had no chronic medical conditions. Since enrollment, participants have been reevaluated every 3–5 years by questionnaires and detailed on-site physical examinations.

Between 1991 and 1999, 797 participants had bone lead content measured by K-shell x-ray fluorescence (KXRF). Of these, 546 also completed a series of questionnaires including questions about optimism and pessimism between 1991 and 1999. The Life Orientation Test was designed to assess optimism as a bipolar dimension, it can also be separated into 2 subscales capturing optimism and pessimism as distinct constructs, with unique relations to health. Therefore, as recommended by many studies (19, 38–40), we considered optimism and pessimism as distinct constructs in the context of this research question. A mean of items assessing pessimistic attitudes was calculated to yield a pessimism score (higher scores indicate greater pessimism). A mean of items assessing optimism was calculated to yield an optimism score (higher scores indicate greater optimism). However, optimism was not associated with lead; thus, we did not pursue further analyses with optimism.

Depressive symptoms were evaluated by using the Brief Symptom Inventory, a 53-item validated questionnaire that assesses 9 primary symptom dimensions including depression (41). Respondents indicated their level of distress on a scale from 0 (not at all) to 4 (extremely). Depression was assessed as present when the depression score was 1 standard deviation above the mean for a normal population (i.e., >0.50) (16).

**Socioeconomic measures**

Four items, ascertained by questionnaire at the time of enrollment, were used to determine childhood SES: 1) paternal education (less than grammar school, grammar school, less than high school, high school, less than college, college, greater than college); 2) maternal education; 3) paternal occupation (skilled, semiskilled, unskilled/foreman, white collar, semiprofessional, professional/managerial); and 4) parental homeownership. These items, ascertained by questionnaire at the early visits, were used to determine adult

This study was approved by the human research committees of Brigham and Women’s Hospital and the Department of Veterans Affairs, and written informed consent was obtained from subjects at each visit.

**Lead measurement**

Bone lead was measured for 30 minutes at the mid-tibia shaft by using KXRF (ABIOMED, Inc., Danvers, Massachusetts). The tibia has been used for bone lead research because it consists primarily of cortical bone, and tibia lead has a long half-life (20–30 years) in the body. The technical specifications and validity of the instrument are described in detail elsewhere (31–33). Two tibia measures with estimated uncertainties greater than 10 µg/g (usually reflecting excessive patient movement during measurement) (29) were excluded (n = 412).

**Psychological measurements**

The Life Orientation Test was used to measure pessimism. This test is made up of 12 items: 4 assessing optimistic attitudes, 4 assessing pessimistic attitudes, and 4 filler questions. Respondents were asked to indicate their degree of agreement with each statement by use of a scale from 0 (strongly disagree) to 4 (strongly agree). In prior research, including work in the Normative Aging Study population, the Life Orientation Test exhibited significant stability over time with high test-retest correlation coefficients (34–37). Although the Life Orientation Test was designed to assess optimism as a bipolar dimension, it can also be separated into 2 subscales capturing optimism and pessimism as distinct constructs, with unique relations to health. Therefore, as recommended by many studies (19, 38–40), we considered optimism and pessimism as distinct constructs in the context of this research question. A mean of items assessing pessimistic attitudes was calculated to yield a pessimism score (higher scores indicate greater pessimism). A mean of items assessing optimism was calculated to yield an optimism score (higher scores indicate greater optimism). However, optimism was not associated with lead; thus, we did not pursue further analyses with optimism.
SES: 1) educational attainment (less than high school, high school, college, greater than college); 2) homeownership; and 3) occupation (white collar, blue collar). On the basis of a prior report in the Normative Aging Study, white collar (working in white collar occupations) and mixed collar (working in both blue and white collar occupations) were grouped together under white collar as these 2 groups appeared similar with respect to lead exposure (42).

Control variables

Control variables included age, health behaviors, and self-rated health, ascertained by questionnaire at the time pessimism was assessed. Health behaviors included pack-years of smoking; smoking status (never, former, current); physical activity (metabolic equivalent task (MET)-hours/week); and self-rated health (from 1 (poor) to 4 (excellent)). For physical activity, where concurrent values were missing, the measure closest to the pessimism assessment was used.

Statistical analysis

**Descriptive statistics.** To address normality, pack-years of smoking and physical activity were log-transformed. To address extreme values of lead, we modeled continuous lead after removing extreme outliers using the extreme-studentized-deviation many-outlier method (43). Results are expressed per interquartile-range increase in lead (14 \( \mu g/g \)). We also modeled lead divided into quartiles as another way to address extreme outliers and to consider possible nonlinearities in relation to pessimism. We compared SES, age, pack-years, physical activity, and depression for those with and without lead or pessimism measure using chi-square and t tests. For these pessimism analyses, we dichotomized pessimism at the median into low (\( \leq 4 \)) versus high (\( >4 \)).

**Structural equation modeling.** Structural equation modeling was used to estimate 1) the relation between lead and pessimism, accounting for the covariance between lead and adult SES; 2) direct and indirect relations between childhood and adult SES and lead in relation to pessimism; and 3) direct and indirect relations among childhood and adult SES, lead, pessimism, and depression.

On the basis of the relations identified in preliminary analyses, age and smoking were included in the equations predicting lead (44), physical activity was included in models predicting pessimism (45), and self-rated health was included in models predicting depression (46).

An index for childhood SES was created (47) as a linear combination of the variables paternal education, maternal education, paternal occupation, and parental homeownership, weighted by the factor score regression coefficients. Similarly, an index of adult SES was created based on educational attainment, homeownership, and occupation. Worth noting is that we also ran structural equation modeling SES as unmeasured latent variables and observed the same associations, but for simplicity we report only models using SES indices.

We used PROC CALIS in SAS, version 9.12, software (SAS Institute, Inc., Cary, North Carolina) to perform structural equation modeling analyses. These analyses used the maximum likelihood method of parameter estimation and were performed on the variance-covariance matrix (48, 49). As depression was a binary outcome, we also used maximum likelihood estimation for the sum of squares and cross-products matrix (50). Model fit was evaluated by using root mean square error of approximation (RMSEA), for which values closer to 0 indicate better fit, and the goodness-of-fit index and Bentler’s comparative fit index for which values closer to 1 indicate better fit (51, 52). Coefficients on the natural scale are reported; however, we also report the standardized coefficients (representing the number of standard deviation changes in the outcome per standard deviation change in exposure). All \( P \) values are 2 sided.

RESULTS

Those with and without a pessimism measure did not differ on childhood and adult SES, age, pack-years of smoking, physical activity, or depression. There were no differences between childhood or adult SES, pack-years of smoking, physical activity, or depression among subjects with or without lead measurement, but those with lead measurement tended to be younger than those without (results not shown).

The mean age of the sample was 68.3 years (standard deviation (SD), 6.37). Five lead values were excluded by the extreme-studentized-deviation method. The mean lead level was 20.6 (SD, 10.7). The mean pessimism level was 4.93 (SD, 2.99), and the mean depression score was 0.22 (SD, 0.39). Table 1 shows the characteristics of participants by higher versus lower pessimism. Compared with those having lower pessimism, those with higher pessimism tended to be older, to be less educated, to have more pack-years of smoking, to be less physically active, to have lower paternal and maternal education and parental occupation, to have higher lead levels, and to be depressed.

Childhood SES was strongly represented by paternal education (e.g., standardized coefficient as factor loading of 0.89; \( P < 0.05 \) ) (Figure 1A). Adult SES was primarily represented by educational attainment (Figure 1B). The greatest reliability of the measure of SES was for educational attainment, with a squared multiple correlation of 0.83; the lowest reliability measure was for parental homeownership, with a squared multiple correlation of 0.01.

For the model of relations among lead, adult SES, and pessimism, the RMSEA was 0.06, the goodness-of-fit index was 0.99, and the comparative fit index was 0.99, indicating acceptable model fit. For the model also accounting for childhood SES, the RMSEA was 0.02, the goodness-of-fit index was 0.99, and the comparative fit index was 1.00, indicating acceptable model fit. With depression added, the RMSEA was 0.02, the goodness-of-fit index, 0.99; and the comparative fit index, 0.99, indicating acceptable model fit.

Lead was positively related to pessimism (standardized coefficient = 0.10; \( P < 0.05 \) ). An interquartile-range increase in lead was related to a 0.37 increase in pessimism score (natural coefficient) (Table 2). This analysis also took into account the correlation (natural covariance of \( -2.88 \); standardized covariance of \( -0.26; \) \( P < 0.05 \) ) between lead and adult SES. In addition, higher adult SES was associated with lower pessimism; adult SES had a larger magnitude standardized...
Table 1. Characteristics of Participants in a Subgroup of the VA Normative Aging Study, United States, between 1991 and 2002

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Low Pessimism (≤4)* (n = 211)</th>
<th>High Pessimism (&gt;4) (n = 201)</th>
<th>P Valuec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>67.6 (6.49)</td>
<td>69.0 (6.16)</td>
<td>0.004</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Less than high school</td>
<td>2.37</td>
<td>5.97</td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>20.4</td>
<td>28.9</td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td>77.3</td>
<td>66.2</td>
<td></td>
</tr>
<tr>
<td>Homeownership</td>
<td></td>
<td></td>
<td>0.89</td>
</tr>
<tr>
<td>Yes</td>
<td>81.7</td>
<td>83.2</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>18.3</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blue collar</td>
<td>29.7</td>
<td>44.1</td>
<td></td>
</tr>
<tr>
<td>White collar</td>
<td>70.3</td>
<td>55.9</td>
<td></td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td>0.91</td>
</tr>
<tr>
<td>Current</td>
<td>8.06</td>
<td>6.97</td>
<td></td>
</tr>
<tr>
<td>Former</td>
<td>60.7</td>
<td>61.7</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>31.3</td>
<td>31.3</td>
<td></td>
</tr>
<tr>
<td>Pack-years of smoking</td>
<td>19.0 (22.2)</td>
<td>24.0 (27.3)</td>
<td>0.01</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td></td>
<td></td>
<td>0.22</td>
</tr>
<tr>
<td>&lt;2 drinks/day</td>
<td>82.5</td>
<td>75.1</td>
<td></td>
</tr>
<tr>
<td>≥2 drinks/day</td>
<td>17.5</td>
<td>24.9</td>
<td></td>
</tr>
<tr>
<td>Physical activity, MET-hours/week</td>
<td>21.8 (23.9)</td>
<td>15.5 (22.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Paternal education</td>
<td></td>
<td></td>
<td>0.004</td>
</tr>
<tr>
<td>Less than high school</td>
<td>57.8</td>
<td>70.9</td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>28.4</td>
<td>20.1</td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td>13.7</td>
<td>8.99</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Less than high school</td>
<td>56.4</td>
<td>72.0</td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>34.3</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td>9.31</td>
<td>4.23</td>
<td></td>
</tr>
<tr>
<td>Paternal occupation</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Unskilled/skilled labor</td>
<td>70.1</td>
<td>81.5</td>
<td></td>
</tr>
<tr>
<td>White collar/professional</td>
<td>29.9</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>Parental homeownership</td>
<td></td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>Yes</td>
<td>43.5</td>
<td>36.6</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>56.5</td>
<td>63.4</td>
<td></td>
</tr>
<tr>
<td>Tibia lead, μg/g</td>
<td>19.6 (12.2)</td>
<td>21.8 (10.9)</td>
<td>0.04</td>
</tr>
<tr>
<td>Depression (&gt;0.50)d</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Yes</td>
<td>12.2</td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>87.8</td>
<td>72.6</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: MET, metabolic equivalent task; SD, standard deviation; VA, Department of Veterans Affairs.

* The cutpoint for high vs. low pessimism was defined by the median level.

b The numbers varied for the covariates physical activity, homeownership, paternal education, maternal education, paternal occupation, and paternal homeownership, with the lowest available for low pessimism and homeownership (n = 202) and for high pessimism and maternal education (n = 189).

c Derived by using chi-square and t tests.

d Depression was assessed as present when the depression score was 1 SD above the mean for a normal population (i.e., >0.50). The numbers for depression were 205 for low pessimism and 197 for high pessimism.
particularly modeled as quartiles of lead (data not shown). Pessimism was attenuated (Table 2) but remained significant, even after controlling for childhood and adult SES. Moreover, older men experiencing low childhood SES and low adult SES had higher cumulative lead levels. In addition, childhood SES and adult SES were associated with pessimism independently of each other and of lead burden. More detailed modeling revealed that lead levels are partly explained by SES and explain some of the effect of SES on pessimism. Secondary analyses considered the association of depression with lead after accounting for childhood and adult SES but did not find direct effects. Only pessimism was directly (but very strongly) associated with depression. The strong relation between pessimism and depression, together with other findings from this study, suggests that lead is an important risk factor for poor psychosocial outcomes net of other risk factors with which it may cluster.

There is emerging research highlighting the importance of exposures across the life course on diseases later in life. Recent evidence indicates that low childhood SES is associated with poorer health in adulthood, over and above adult SES levels (1, 53–57). Chen et al. (58) found that, in children, low SES is associated with stress-related hormonal trajectories. These researchers hypothesized that SES may affect the way children interpret their social world. Low SES environments may be characterized by chronic stress coupled with fewer coping resources; individuals in these environments may adapt to their circumstances by being highly vigilant (59, 60). This coping strategy may, over time, solidify into a relatively stable attribute of expecting negative outcomes, that is, being dispositional pessimism. However, there was a strong relation between pessimism level and depression. A 1-unit increase in pessimism level was associated with an increased likelihood of being in the high depression group (odds ratio = 1.04, 95% confidence interval: 1.02, 1.05). For all models, covariates were significantly associated with the outcome (e.g., physical activity was significantly negatively associated with pessimism).

### DISCUSSION

We considered the relation between cumulative lead and dispositional pessimism and also examined the role of SES over the life course in the lead-pessimism relation. Tibia lead predicted levels of pessimism even after accounting for childhood and adult SES. Moreover, older men experiencing low childhood SES and low adult SES had higher cumulative lead levels. In addition, childhood SES and adult SES were associated with pessimism independently of each other and of lead burden. More detailed modeling revealed that lead levels are partly explained by SES and explain some of the effect of SES on pessimism. Secondary analyses considered the association of depression with lead after accounting for childhood and adult SES but did not find direct effects. Only pessimism was directly (but very strongly) associated with depression. The strong relation between pessimism and depression, together with other findings from this study, suggests that lead is an important risk factor for poor psychosocial outcomes net of other risk factors with which it may cluster.

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### Table 2. Differences in Pessimism Associated With Adult and Childhood SES and Tibia Lead Using Natural Scale (Unstandardized) Units (95% Confidence Interval) Controlling for Age and Health Behaviors (n = 407) in a Subgroup of the VA Normative Aging Study, United States, between 1991 and 2002

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1 (Tibia and Adult SES)</th>
<th>Model 2 (Tibia, Adult, and Childhood SES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect Estimate</td>
<td>95% CI</td>
</tr>
<tr>
<td>Tibia lead (per IQR increase)</td>
<td>0.37*</td>
<td>0.07, 0.66</td>
</tr>
<tr>
<td>Adult SES (per 1-unit increase)</td>
<td>-0.47*</td>
<td>-0.68, -0.25</td>
</tr>
<tr>
<td>Childhood SES (per 1-unit increase)</td>
<td>-0.42*</td>
<td>-0.80, -0.04</td>
</tr>
<tr>
<td>R²</td>
<td>0.09</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; IQR, interquartile range; SES, socioeconomic status; VA, Department of Veterans Affairs.

* P < 0.05 (using structural equation modeling).

* IQR increase: 14 µg/g.
Adults with low educational attainment are more likely to work in low SES environments can increase lead absorption and its effects of a given level of lead (5, 61, 62), which may be influenced by circumstances related to SES such as increased stress and poorer nutrition and health care (9). For example, children in low SES environments are more vulnerable to the accumulating evidence in both human and animal studies that vascular and hormonal responses to acute stress. There is also a significant mediator of the association between SES and mental and physical health outcomes has been the increased found adult SES and cumulative lead to be related. This likely indicates other pathways by which childhood SES impacts adult cognitive orientation. It may also indicate that the developmental origins of pessimistic orientation are evident in childhood and have lasting effects into adulthood.

One explanation for the relation between SES and various mental and physical health outcomes has been the increased risk of environmental toxicant exposure with low SES status. Gump et al. (5, 8) found that, in children, blood lead was a significant mediator of the association between SES and vascular and hormonal responses to acute stress. There is also accumulating evidence in both human and animal studies that children in low SES environments are more vulnerable to the effects of a given level of lead (5, 61, 62), which may be influenced by circumstances related to SES such as increased stress and poorer nutrition and health care (9). For example, deficiencies in calcium or iron frequently observed in children in low SES environments can increase lead absorption and its effect on the brain (61).

We found adult SES and cumulative lead to be related. Adults with low educational attainment are more likely to work in blue collar jobs that tend to have greater lead exposure and to live in lead-rich environments. In another Normative Aging Study, Elreedy et al. (63) found a relation between individual and community-level low educational attainment and higher tibia lead levels. Also in the Normative Aging Study, Elmarsafawy et al. (42) found that blue collar workers had on average 5.5 μg/g higher tibia lead levels. Conversely, lead in childhood may affect adult SES through its inverse relation with cognitive achievement. Worth noting is that the effect of adult SES on pessimism, although attenuated after factoring in childhood SES, was still a significant predictor of lead and pessimism. Similarly, Ek et al. (64) found that adult achievement, independent of early relations and parental SES, was an important predictor of optimism.

As far as we know, this is the first study to investigate the association between cumulative lead and pessimism. Our findings of a positive association are congruent with findings of a relation between lead burden and depressive symptoms, particularly seen in occupational studies, which can be influenced by a pessimistic orientation (15, 65–70). In this study, we found no direct relation with depression but an indirect relation through lead’s association with pessimism, congruent with other studies finding an association between cumulative low-level lead and depression.

The etiologic mechanisms underpinning lead and emotional processing have not been fully elucidated (15). It is not clear if psychological problems are caused directly by lead-induced brain damage or are secondary to conditions surrounding its effect on cognitive performance (61). Poor academic performance could lead to loss of self-esteem, poor social development, and general expectation of negative outcomes (61). However, there is some indication that lead may affect the brain systems that regulate social/emotional functioning (61, 71). Physiologically, lead is thought to alter the functioning of the hypothalamic-pituitary-adrenal axis either directly or indirectly, the latter mediated by inducing alterations in neurochemical function (3). Lead may interfere with the release of neurotransmitters by mimicking or inhibiting calcium-mediated processes (3, 72–74).

There are some limitations to this study. Other work has found that pessimism among children predicted more parent-reported social and academic deficits (75). Pessimism could thus have affected cognitive functioning and thereby adult social and economic position and life choices that could increase lead exposure, although including measures of child social environment mitigates some of this concern. The role of genetics (heritability) versus environment (learning) on mental health status has been a matter of debate. Pessimism is characterized as a trait (76). Similar to other traits, it has a heritability factor of 27%, suggesting that it is also partially learned and elaborated over the life course (77, 78). Other research has found a graded association between optimism/pessimism and SES (22, 79) and patterning in optimism by changes in SES between childhood and adulthood (60), further providing evidence that while pessimism may be relatively stable in the absence of efforts to alter it (likely in low-income environments), it can be changed where resources are available (80). So although pessimism is characterized as a trait, it is one that is partially learned and therefore is unlikely to be fully elaborated prior to lead exposure.

Because there was little variability in depression scores (over 50% of the participants had a zero score resulting in a zero-inflation problem), we used depression as a binary variable, a more limited measure than is perhaps ideal (16). Also, interpretation of the results may be less clear where lead is divided into quartiles and distances between quartiles tend to vary. Other limitations include the determination of childhood SES based on retrospective recollection. However, studies have shown that objective information such as parent’s education and occupation can be measured this way reliably (14). Although we based childhood SES on a number of different factors, we did not have a measure of family income; however, we did account for homeownership, an index of wealth. In addition, it has been found that parental education and occupation are more important than family finances on outcomes such as cognitive functioning (14). We also had limited assessment of adult SES, basing it on educational attainment.
occupational category, and homeownership. Finally, this study may have limited generalizability, being a male cohort that is 97% white. Despite these limitations, this study makes an important contribution in addressing the relation among psychosocial resources, a long-term environmental exposure, and SES over the life course.

In summary, we found that higher cumulative lead was associated with higher pessimism, taking into account childhood and adult SES as well as age and health behaviors. Childhood and adult SES were negatively related to lead and associated with greater pessimism independently of each other and lead burden; adult SES was the larger contributor to pessimism. These findings suggest that lead burden and adult SES can affect pessimistic orientation and ultimately depression in later adulthood.

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REFERENCES


