HHS Public Access

Author manuscript

J Public Health Manag Pract. Author manuscript; available in PMC 2024 January 01.

Published in final edited form as:

J Public Health Manag Pract. 2023 ; 29(2): 241–249. doi:10.1097/PHH.0000000000001623.

Evaluating the Effectiveness of State-Level Policies on Childhood Blood Lead Testing Rates

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Abstract

Context: Lead exposure can harm nearly every organ in the human body. Millions of US children are exposed to lead hazards. Identifying lead-exposed children using blood lead testing is essential for connecting them to appropriate follow-up services. However, blood lead testing is not consistently conducted for at-risk children. Thus, determining which policies help improve blood lead testing rates is essential.

Objective: This analysis provides critical evidence to better understand which state-level policies are more effective at increasing childhood blood lead testing rates. These include metrics, incentives, other managed care organization guidance, provider guidelines, mandatory reporting of results to state health departments, data sharing between Medicaid and other state agencies, and proof of testing for school enrollment.

Design: This analysis included 33 states with complete data on the number of children tested for blood lead in 2017–2018 as reported to the Centers for Disease Control and Prevention.

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The authors acknowledge Joe Courtney, for his advice and guidance during manuscript preparation, Stella Chuke, Qaiyim, and Harris, for preparing the data set used in this analysis, and Luke Naeher, for his service on the dissertation committee.

The findings and conclusions in this report are those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (http://www.JPHMP.com).

Linear regression modeling was conducted to examine associations between testing rates and the aforementioned policies. Fully adjusted models included percentages of the population living in pre-1980 housing, younger than 6 years with Medicaid coverage, and foreign-born.

Results: Strongest unadjusted and adjusted regression coefficients were observed for requiring proof of testing for school enrollment ($\beta = .12$, $P = .03$) and metrics ($\beta = .06$, $P = .01$), respectively.

Conclusion: Policies associated with higher childhood blood lead testing rates can be used by policy makers; local, state, and federal public health agencies; professional organizations; nonprofit organizations; and others to inform development and implementation of additional policies to increase childhood blood lead testing.

Keywords

blood lead levels; blood lead testing; childhood lead poisoning; increasing blood lead testing rates

Lead exposure can affect most body systems, with neurological, renal, cardiovascular, hematological, immunological, reproductive, and developmental effects being the most studied endpoints.[1,2] Children are more impacted by lead because of their hand-to-mouth behaviors and rapidly developing brains and nervous systems.[2] It is recognized among public health professionals and clinicians that no safe level of lead in children's blood has yet been identified.[3]

Despite several laws enacted beginning in the 1970s to control lead exposure, children may still be exposed to lead in paint, soil, water, toys, jewelry, food, cosmetics, and traditional home remedies.[3] Deteriorated lead-based paint in homes built before 1978 can create lead-contaminated chips and dust and contaminate soil if not properly maintained, repaired, or removed.[4] Approximately 3.3 million homes in the United States with children younger than 6 years have significant lead-based paint hazards.[5] In addition, children can be exposed to legacy contamination from leaded gasoline in urban areas and near major roadways.[3] Children who are Black or living in low-income households face disparities in blood lead levels (BLLs).[6] These populations are less likely to have access to quality housing and may be discriminated against when looking for a safe, healthy place to live. This inequity makes these populations more susceptible to exposure from living in homes that contain leaded paint, pipes, faucets, and plumbing fixtures.

Primary and secondary prevention of lead poisoning is necessary to eliminate exposure to lead and associated adverse health effects.[3] In the absence of primary prevention, secondary prevention—such as conducting blood lead testing—is vital to identifying which children have BLLs that trigger public health action that is essential for connecting them to appropriate follow-up services to mitigate adverse health effects.[7,8] Several lead testing policies focus on Medicaid-eligible children, who have a higher risk of childhood lead poisoning in the United States, such as requiring state Medicaid programs to test all Medicaid-eligible children at 1 and 2 years of age.[8,9] A 2018 report categorized the following policies that promote childhood blood lead testing for each state[10]:

1. Metrics are measures of health care system quality that can be aggregated and analyzed to quantify improvements in health care quality and system performance.[11] The commonly used Health Plan Employer Data and Information Set (HEDIS) measure for childhood lead poisoning is the percentage of children 2 years of age who received a blood lead test by their second birthday.[12]

2. Incentives that use financial and nonfinancial rewards to motivate health care providers to strive for improvements in quality, efficiency, and costs.[13]

3. Other managed care organization (MCO) guidance, including using performance improvement plans that can be tailored to specific areas of concern and value-based purchasing.[14,15]

4. State-specific provider guidelines for childhood blood lead testing, either mandatory or recommended.[8]

5. Data sharing across agencies and with MCOs, which can assist with developing appropriate jurisdiction-specific testing recommendations and policies.[16]

6. Mandatory reporting of blood lead data to state health departments.[15]

7. Requiring proof of blood lead tests as a condition for school enrollment, generally for pre-K or kindergarten.[8]

Although the American Academy of Pediatrics recommended that pediatricians and public health officials be aware of jurisdiction-specific requirements and professional guidance for childhood blood lead testing, a recent analysis found that testing policies are not effectively communicated to health care providers.[17,18] Furthermore, statutory requirements are not being enforced. According to a 2017 report, 45 states and the District of Columbia maintain that they follow universal testing requirements for Medicaid-enrolled children.[8] In addition, several states have policies for testing non–Medicaid-enrolled children. However, the report found that no states achieved full compliance with Medicaid or state testing requirements.[8] Because of varied state approaches and resulting testing rates, determining which policies are most effective is needed to improve testing rates.

Regardless of testing mandates, providers may let their inherent biases dictate which children to test and therefore may miss identifying a child who needs appropriate follow-up services. One study found that although most providers were aware of testing requirements for Medicaid-enrolled children, one-third erroneously believed their practice was in a low-risk area and did not test.[19] Another study found that pediatricians were less likely to test if they believed that adverse health effects did not occur at BLLs of less than 10 μg/dL, disagreed with the state's testing recommendations, and served a low percentage of Medicaid-enrolled patients.[20] These studies further demonstrate the need for determining the most successful policies to inform providers' testing decisions.

A study conducted in New York showed that enacting a policy that required reporting of all blood lead tests was effective at increasing testing rates by 14% in a 1-year period.[21] However, more studies are needed to examine the relationship between policies and testing rates. This analysis helps address this gap in the literature by providing critical evidence to better understand which state-level policies are more effective at increasing childhood blood lead testing rates.

Methods

To assess associations between childhood blood lead testing rates and state-level testing policies, a data set was constructed from 3 sources: (1) 2017–2018 lead testing data on children younger than 6 years reported to the Centers for Disease Control and Prevention (CDC) Childhood Blood Lead Surveillance (CBLS) system; (2) the 2018 report that categorized state policies that promote childhood lead testing; and (3) US Census data on potential confounders. CBLS testing data from 2017 to 2018 were chosen because the policy categorization report was published in 2018. Therefore, information collected for the report likely reflects the policy landscape in 2017, and 2018 was the most recent year that complete CBLS data were available when the analysis was conducted. The CBLS system was exempt from CDC's institutional review board review because it is public health practice surveillance data.

CDC's core lead poisoning prevention strategies are to strengthen blood lead testing and reporting, surveillance, linkages of lead-exposed children to recommended services, and targeted, population-based interventions.[22] In 2017–2018, 53 funded programs provided standardized lead testing data to CBLS. Only 34 programs (32 states, New York City, and the District of Columbia, which was considered a state for this analysis) are included in the primary analysis because complete data for 2017–2018 were available for the entire jurisdiction covered by their childhood lead poisoning prevention program. CBLS data from New York City and New York State were merged before analysis. In 2018, the 53 funded programs reported testing data on 3.3 million children.

All states were reported to have at least one lead testing policy, but no state used all the reported approaches. Based on information from the literature, 2017 US Census data on the following potential confounders (percentages) were obtained for each state in the analysis: housing built before 1980, Black alone or in combination with other races, foreign-born, persons 25 years and older with at least a high school diploma ("education"), and population younger than 6 years with Medicaid coverage.[23–25]

Data analysis

To calculate "childhood blood lead testing rates," state populations of children younger than 6 years were obtained from the US Census.[26] State populations for age less than 6 years for 2017 and 2018 were estimated by using data for age less than 5 years in that year and adding 0.2 * (number for ages 5–9 years). The proportion of children tested during 2017–2018 was calculated by dividing the average of the numerators (numbers of children tested) by the average of the denominators (population <6 years of age) and for the 2 years. For the policies, the "other requirements" category in the 2018 report was further classified into meaningful subcategories: mandatory reporting of BLL test results to state health departments, data sharing between Medicaid and other state agencies, and requiring proof of blood lead tests as a condition for school enrollment.

Modeling was conducted to assess the effect of different policies on testing rates. Associations between testing rates, measured as a continuous dependent variable and state policies, a categorical variable, was conducted using linear regression.[27] If regression coefficients for policies differed by 10% or more when comparing results from the unadjusted and adjusted models for most policies, then the risk factor was included in fully adjusted models.[28] Pearson correlations coefficient among potential risk factors for lead testing were conducted to assess collinearity and help determine which variables to include in adjusted models.

Sensitivity analyses were done by conducting the prior analyses with the addition of the 5 additional states that participated in CBLS but whose 2017–2018 surveillance data were incomplete or unavailable in CDC's cleaned and edited data set. For these 5 states, 2017 data on lead testing rates were available from the states' Web sites; however, 2018 data were unavailable. Therefore, sensitivity analyses only included 2017 childhood blood lead testing rates.

Modeling testing rates as a categorical variable was also explored. Odds ratios could not be calculated using cut points at the 90th or 75th percentiles of testing rates because of sparse data. Using a cut point at the 50th percentile grouped together states with very different testing rates; for example, Massachusetts and Oklahoma, which had testing rates of 48% and 17%, respectively.

Interpretation was based on magnitude of the point estimates regardless of statistical significance in conjunction with width of the confidence interval (CI) (as a proxy for the precision of the estimate), model assumptions, uncertainties, evaluation of biases, and coherence.[29–31] When considering other contextual factors, a nonstatistically significant result may still provide useful information for public health action. Conversely, a statistically significant result may lack scientific and public health significance.[29]

Results

The Figure displays states included in the primary (n = 33) and sensitivity (n = 38) analyses. Ten states were excluded from the primary analysis because of incomplete testing data for 2017–2018. In addition, 8 states were excluded from analyses because they did not participate in CBLS during 2017–2018. The number of policies per state ranged from 1 to 5, with an average of 3 per state (Table 1). The most frequent strategy was provider guidelines (n = 35). The proportion of children younger than 6 years tested for BLLs in 2017–2018 in states included in the analysis ranged from 0.04 to 0.48, with an average of 0.17 (Table 1).

The distribution of potential confounders by state is presented in Supplemental Digital Content Table 1 (available at http://links.lww.com/JPHMP/B47). Education was highly negatively correlated with the percentage of the population younger than 6 years with Medicaid coverage ($r = -0.66$, $P < .01$). Therefore, education was excluded from fully adjusted models because the literature indicated that providers use the percentage of their patient population enrolled in Medicaid to make decisions about blood lead testing.[23,24] Data did not show a correlation between race and pre-1980 housing ($r = -0.04$, $P = .81$).

Primary analyses

Unadjusted regression coefficients for the proportions of children tested for BLLs in 2017–2018 ranged from 0.03 for mandatory reporting of results to state health departments to 0.12 for requiring proof of testing for school enrollment (Table 2). All models were fully adjusted for the following confounders: percentages of the population living in housing built before 1980, population younger than 6 years with Medicaid coverage, and foreign-born. Metrics had the highest adjusted regression coefficient (0.06; 95% CI: 0.01, 0.11; $P = .01$) (Table 2), followed by other MCO guidance (0.04; 95% CI: −0.03, 0.11; $P = .28$) and mandatory report of results to state health departments (0.04; 95% CI: −0.01, 0.09; $P = .08$).

Sensitivity analyses

Unadjusted regression coefficients for proportions of children tested for BLLs in 2017 ranged from 0.03 for mandatory reporting of results to state health departments to 0.07 for requiring proof of testing for school enrollment (Table 3). Models were fully adjusted for the same confounders used in the primary analyses. Metrics had the highest adjusted regression coefficient (0.04; 95% CI: −0.01, 0.08; $P = .11$) (Table 3), followed by mandatory reporting of results to state health departments (0.03; 95% CI: −0.01, 0.08; $P = .17$). Differences between these results and the primary analyses can be found by comparing Tables 2 and 3.

Discussion

In the current analysis, both unadjusted and adjusted results provided useful contributions for determining the most effective policies. Unadjusted results are highlighted because of concerns about including too many variables in adjusted models when data are limited by the small number of states analyzed. For example, requiring proof of testing for school enrollment produced the strongest unadjusted regression coefficients in both the primary and sensitivity analyses, which suggests this policy may be an important lever to promote increased childhood blood lead testing. However, according to the 2018 report, only 5 states used this approach.[10] Enacting and enforcing a policy requiring proof of testing for school enrollment may help overcome challenges providers face when they schedule testing appointments and parents either decline or miss appointments due to the strong disincentive of noncompliance with school enrollment requirements for parents who do not follow up on recommended lead testing appointments.[32] While school-age children are generally older than the peak ages for BLLs (children <3 years),[17] policies requiring proof of testing for school enrollment can still help to encourage testing by creating more awareness of lead poisoning and facilitating testing in younger siblings. Reporting of lead metrics produced the strongest adjusted regression coefficients in both the primary and sensitivity analyses. Slightly more than 50% of the states were reported to use metrics to increase childhood blood lead testing. Some states have tied improvements in metrics to financial incentives.[13,16]

Data on the proportion of children younger than 6 years tested for lead in Table 1 should not be considered as absolute numbers because denominators included all children in the state estimated to be younger than 6 years, and numerator data represented blood lead testing in children that is typically focused on 1- and 2-year-olds. This may help explain why testing rates appear to be low. Besides Medicaid coverage, data on risk factors represented the entire population of the state and were not limited to children younger than 6 years and therefore may not accurately capture the true distribution of risk in young children. The percentage of the population living in pre-1980 housing does not account for housing that has been renovated and no longer presents a lead hazard.

Public health significance and implications

Evidence on effective policies such as that provided in the current study can help ensure that at-risk children are tested so they can be connected to appropriate follow-up services. Sharing information on which specific policies were associated with higher testing rates could increase testing. Given that a substantial proportion of US children did not receive blood lead tests, the true magnitude of children exposed to lead is unknown and likely higher than currently enumerated.[18] Increasing blood lead testing rates will likely help public health practitioners to understand the true distribution of childhood BLLs and allow for limited resources to be prioritized appropriately, particularly for underserved communities and children at risk for lead exposure. Increased testing will likely result in more complete and accurate data so that public health professionals, health care providers, and communities can better understand dose-response relationships between environmental and BLLs, which interventions are most effective, and which geographic locations and populations are at a higher risk of exposure.[33]

When children with lead exposure are connected to behavioral services and early learning interventions, they are more likely to exhibit academic readiness, spend less time in special education, graduate high school, and have reduced contact with the criminal justice system.[34] Investing in programs to mitigate adverse effects experienced by children with lead exposure, such as early education services, is also very cost-effective from a societal perspective. For example, a recent report estimated that every dollar invested in early childhood education produces $8.60 in benefits to society.[33]

Research shows that public health policies enacted and implemented at the local, state, or federal level can create sustainable impact and influence large numbers of people.[35] Policy interventions that change the environmental context can be more effective than other public health actions because they require fewer behavior changes.[36] For example, policies that ban smoking in public places are likely to impact more people than a campaign that encourages individuals to quit smoking. Findings from this analysis provide evidence that can be used to support developing additional testing policies in jurisdictions that have lower proportions of children who receive blood lead testing compared with other similar jurisdictions.

Strengths and limitations

After a thorough review of the existing literature, the authors believe this is the first in-depth nationwide analysis of how policies to promote testing are associated with childhood blood lead testing rates. Strengths of this analysis include the ability to analyze large numbers of children tested; ability to evaluate the impact of public health strategies; convenience because of conducting a secondary data analysis; and a lack of ethical issues common to public health studies (autonomy, privacy, and confidentiality) since the study relied on surveillance data.[37]

Limitations of the analysis include the inability to include testing data from nonparticipating states or states whose data were incomplete; inability to attribute associations at the individual level; difficulty in inferring causality; unmeasured confounding; testing protocols vary by state; assumption that the 2018 report that categorized policies that promote childhood blood lead testing was error-free; and potential misclassification such as whether some of children received a blood lead test in a neighboring state that had different policies. One geographical anomaly is that most states in the Great Plains were not represented in this analysis.

Conclusion

Policies are a public health strategy that can be used to increase childhood blood lead testing rates. In this study, states that required proof of testing for school enrollment and used metrics had higher testing rates. Currently, only a limited number of states employ these approaches. Jurisdictions should be aware of these policies when implementing new approaches to increase testing rates since lead-exposed children who receive public health interventions are more likely to exhibit academic readiness, spend less time in special education, graduate high school, and have reduced contact with the criminal justice system, which has social and economic benefits for society. Further research is needed to understand whether these policies could be an effective tool for increasing lead testing rates in other jurisdictions. In addition, more research into how the proportion of children who receive blood lead testing varies by sociodemographic characteristics (eg, race, ethnicity, income, urbanicity) would be helpful. Knowing which subpopulations are more likely to have low proportions of children receiving blood lead tests will assist childhood lead poisoning prevention programs in addressing issues related to health equity and environmental justice. Reducing gaps and inconsistencies in data collection and reporting is important to enhance the quality of BLL surveillance data.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Implications for Policy & Practice

- Millions of US children are exposed to significant lead hazards, which can negatively affect a child's intelligence, ability to pay attention, and academic achievement.
- Identifying children with lead exposure using blood lead testing is essential for connecting them to appropriate follow-up services to mitigate adverse health effects.
- A 2017 report found that no states achieved full compliance with federal or state childhood blood lead testing requirements.
- Requiring proof of blood lead testing for school enrollment and requiring reporting of lead metrics were associated with higher proportions of children who receive blood lead testing.
- Promoting effective policies is a tool that can be implemented by decision makers, public health agencies, and others to encourage increases in childhood blood lead testing.

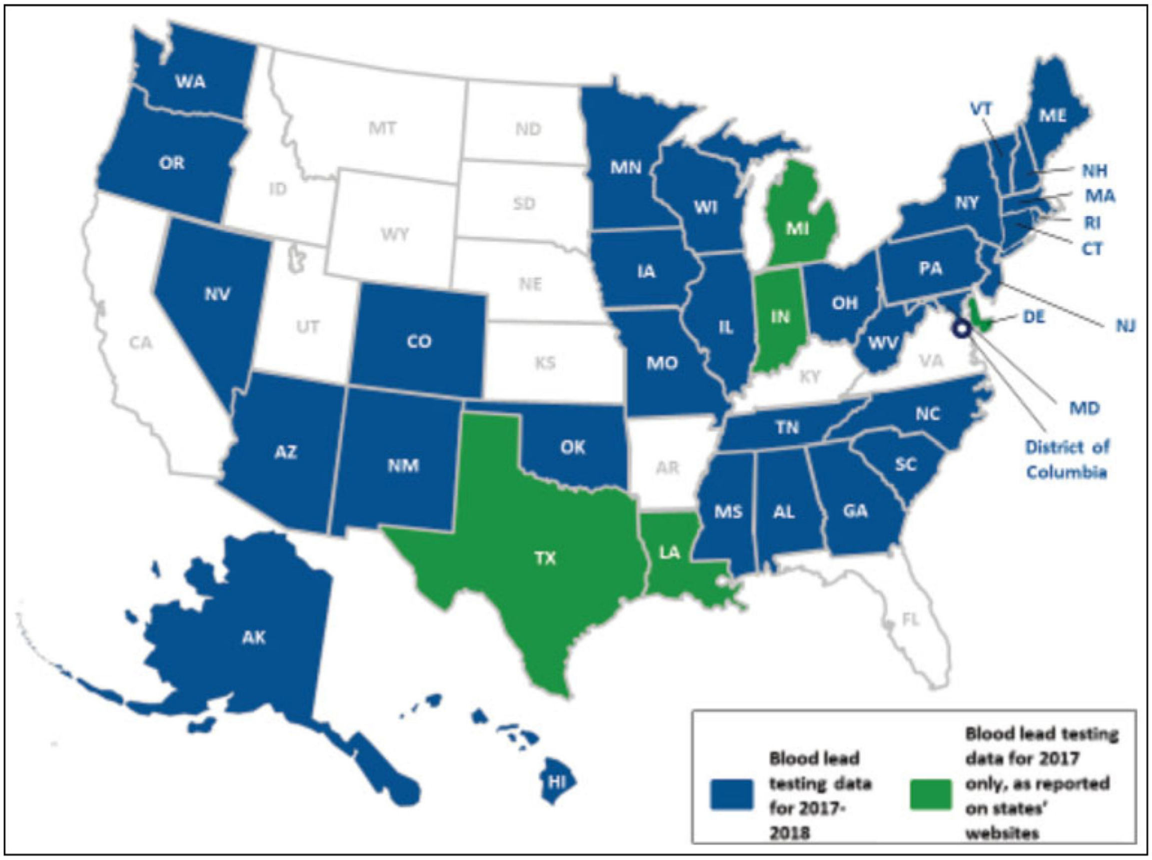

FIGURE.

States Included in the Analysis of the Association Between Childhood Blood Lead Testing Rates and Blood Lead Testing Policies and Strategies This figure is available in color online (www.JPHMP.com)

TABLE 1

Lead-Related Testing Strategies and Policies and Proportion of Children Tested for Blood Lead Levels in 2017–2018, by State

State	Metrics	Incentives	MCO Guidance	Provider Guidelines	Mandatory Reporting to State Health Department	Data Sharing Between Medicaid and Other State Agencies	Proof of Testing Required for School Enrollment	State Total	Proportion of Children Tested
Alabama	0	0	0	1	1	0	0	2	0.11
Alaska	0	0	0	1	1	0	0	2	0.05
Arizona	0	0	0	1	0	0	0	1	0.15
Colorado	0	0	0	1	0	0	0	1	0.06
Connecticut	0	1	0	1	1	1	0	4	0.32
Delaware[a]	1	0	0	1	1	0	1	4	0.02
District of Columbia	1	0	0	1	0	0	0	2	0.32
Georgia	1	1	0	1	0	0	0	3	0.14
Hawaii	0	0	0	1	0	0	0	1	0.16
Illinois	0	1	0	1	1	0	1	4	0.19
Indiana[a]	1	1	1	1	1	0	0	5	0.12
Iowa	1	0	1	1	0	1	1	5	0.26
Louisiana[a]	1	0	1	1	1	0	0	4	0.15
Maine	0	1	0	1	0	0	0	2	0.17
Maryland	1	0	1	1	1	0	0	4	0.3
Massachusetts	1	0	1	1	1	0	0	4	0.48
Michigan[a]	1	1	0	1	0	0	0	3	0.22
Minnesota	0	1	0	1	0	0	0	2	0.22
Mississippi	0	0	0	1	1	1	0	3	0.17
Missouri	0	1	1	1	1	0	0	4	0.18
Nevada	1	0	0		1	0	0	2	0.04
New Hampshire	0	0	0	1	0	0	0	1	0.22
New Jersey	1	1	1	1	1	0	0	5	0.27
New Mexico	1	0	0	1	0	0	0	2	0.08
New York State	1	1	0	1	1	0	1	5	0.36
North Carolina	1	0	0	1	1	0	0	3	0.17

State	Metrics	Incentives	MCO Guidance	Provider Guidelines	Mandatory Reporting to State Health Department	Data Sharing Between Medicaid and Other State Agencies	Proof of Testing Required for School Enrollment	State Total	Proportion of Children Tested
Ohio	0	0	0	1	0	0	0	1	0.2
Oklahoma	1	1	0	1	1	0	0	4	0.17
Oregon	0	0	0	1	1	0	0	2	0.06
Pennsylvania	0	0	1	1	0	1	0	3	0.17
Rhode Island	1	1	0	1	1	0	1	5	0.39
South Carolina	1	1	0	1	1	0	0	4	0.13
Tennessee	1	1	0	1	1	0	0	4	0.17
Texas[a]	0	0	1	1	1	0	0	3	0.13
Vermont	0	0	0	1	1	0	0	2	0.26
Washington	0	0	0	1	0	0	0	1	0.04
West Virginia	1	0	0	0	0	0	0	1	0.15
Wisconsin	1	0	1	0	1	1	0	4	0.23
Total	20	14	10	35	23	5	5		

Abbreviation: MCO, managed care organization.

[a]% of children tested reported for 2017 only using publicly available data on states' Web sites; these states are only included in the sensitivity analyses.

TABLE 2

Unadjusted and Adjusted Results of Associations Between Blood Lead Testing Policies/Strategies and the Proportion of Children Tested for Blood Lead Levels in 2017–2018

Policy	Unadjusted Regression Coefficient	95% Confidence Interval	*P*	Adjusted Regression Coefficient[a]	95% Confidence Interval	*P*
Proof of testing required for school enrollment	0.12	0.01, 0.23	.03	0.01	−0.08, 0.10	.84
Other MCO guidance	0.10	0.01, 0.18	.03	0.04	−0.03, 0.11	.28
Metrics	0.07	0.00, 0.21	.06	0.06	0.01, 0.11	.01
Provider guidelines	0.06	−0.07, 0.19	.34	0.02	−0.07, 0.11	.69
Incentives	0.05	0.00, 0.13	.18	0.02	−0.03, 0.07	.47
Data sharing between Medicaid and other state agencies	0.04	−0.06, 0.15	.40	0.00	−0.07, 0.08	.93
Mandatory reporting to state health departments	0.03	−0.03, 0.12	.22	0.04	−0.01, 0.09	.08

Abbreviation: MCO, managed care organization.

[a]Adjusted for age of housing, population younger than 6 years with Medicaid coverage, and foreign-born.

TABLE 3

Unadjusted and Adjusted Results of Associations Between Blood Lead Testing Policies/Strategies and the Proportion of Children Tested for Blood Lead Levels in 2017

Policy	Unadjusted Regression Coefficient	95% Confidence Interval	*P*	Adjusted Regression Coefficient[a]	95% Confidence Interval	*P*
Proof of testing required for school enrollment	0.07	−0.03, 0.17	.19	−0.03	−0.10, 0.05	.48
Other MCO guidance	0.06	−0.02, 0.14	.12	0.02	−0.04, 0.07	.50
Metrics	0.05	0.11, 0.21	.13	0.04	−0.01, 0.08	.11
Provider guidelines	0.05	−0.08, 0.18	.42	0.01	−0.08, 0.10	.85
Incentives	0.05	−0.02, 0.13	.12	0.02	−0.04, 0.07	.54
Data sharing between Medicaid and other state agencies	0.05	−0.05, 0.16	.29	0.01	−0.06, 0.09	.73
Mandatory reporting to state health departments	0.03	−0.04, 0.10	.45	0.03	−0.01, 0.08	.17

Abbreviation: MCO, managed care organization.

[a] Adjusted for age of housing, population younger than 6 years with Medicaid coverage, and foreign-born.