Technical Documentation for the Analytical Approach to Identify High-Risk Communities for Universal Blood Lead Testing in Michigan

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Executive Summary

As the Michigan Department of Health and Human Services (MDHHS) seeks to reduce lead exposure for children, it is important to identify methods for tailoring activities based on lead exposure risk, severity of impact of that exposure and equity in community and household capacity to mitigate or avoid exposure.

This documentation provides a description of the methodology used to identify the communities in Michigan where children are at an elevated risk of lead exposure (as indicated by blood lead testing results) while also considering age of housing stock and socioeconomic vulnerability. As part of the State of Michigan universal lead testing requirements for children less than 6 years old, MDHHS is responsible for creating rules pertaining to "the identification of geographic areas in this state that pose a high risk for childhood lead poisoning and a requirement that a minor who is 4 years of age be tested if the minor resides in an area described in this subdivision." [1] The approach detailed here entails a comprehensive analysis of the incidence rates of elevated blood lead levels (EBLLs) at or above 3.5 micrograms per deciliter of blood (µg/dL) for children under the age of 6 years to identify geographic areas per this requirement.

Key Features of the Report:

1. Prioritization of High-Risk Communities: The approach establishes a framework designed to identify and prioritize communities where children have a higher level of lead exposure risk. This framework defines communities using the United States Census Bureau's geography of Minor Civil Division (MCD).[2]
2. Analysis of EBLL Incidence Rate: This report describes the incidence rates of EBLLs at or above 3.5 µg/dL among children under the age of 6 for Michigan's MCDs. The analysis uses blood lead testing data for the five-year period from 2018 to 2022.
3. Modification of Incidence Rates: This framework includes the modification of the five-year EBLL incidence rates using community-level child poverty rates and the prevalence of older housing (a potential source of lead exposure via lead-containing paint) from the U.S. Census Bureau.
4. Comparative Analysis: This approach compares the modified incidence rates of elevated blood lead levels for individual MCDs with the incidence rate for the entire state during the same time.

By focusing on children under the age of 6, this report addresses a population that is particularly vulnerable to the effects of lead exposure. The insights from the identification and prioritization of MCDs with children at the highest risk provide a foundation for decision-makers to implement effective strategies, policies and interventions aimed at reducing the incidence of elevated blood lead levels as it relates to universal testing requirements.

Purpose

The goal of this model is to identify communities with an elevated risk of childhood lead exposure per the requirements of universal blood lead testing law in Michigan. The analysis evaluates risk by examining five-year incidence rates of EBLLs, the age of housing units and poverty levels across the 1,520 Minor Civil Divisions (MCDs) in Michigan.

Methods

Briefly, the approach used here calculates and modifies EBLL incidence rates for each MCD and compares them to the statewide incidence rate. An approach that estimates community-level risk based on incidence rates alone misses the influence on populations burdened with poverty and health inequities. Income and housing are closely related, with those in poverty often living in older homes.[3] Living in older homes often carries a greater risk of exposure to lead through dust, paint chips and older plumbing. Therefore, considering poverty and housing is imperative to identify communities most at risk of lead exposure. This analysis is designed to comparatively evaluate a community's risk of lead exposure to optimize the use of resources and inform preventive programs. This approach was adapted from one used by the Massachusetts Department of Public Health; for more information about how this analysis differs from that used in Massachusetts see the Appendix.

Data Used for Analysis

Blood lead testing data used in this analysis were obtained from the Michigan Department of Health and Human Services Childhood Lead Poisoning Prevention Program (CLPPP) blood lead surveillance database, where laboratory reports of blood lead test results are managed. Data for this report were pulled on March 31, 2023 and include results for calendar years 2018-2022.

Blood lead test results are for Michigan children who were under age 6 at the time of the test. This age group is the focus of childhood lead poisoning prevention programmatic efforts within the Centers for Disease Control and Prevention (CDC).[2]

There was moderate fluctuation in testing in Michigan between 2010 and 2019 with the number and percent of children under 6 years old who received a blood lead test ranging from 155,957 (21.0%) to 143,285 (21.0%) annually during this period. However, during the COVID-19 pandemic, the number of tests decreased sharply to 97,199 (14.2%) in 2020 and only partially recovered to 108,080 by 2022 (15.8%).

To minimize the influence of fluctuating testing rates and the impact on an individual child's potentially repeated testing across this period, the highest and most accurate test value available was selected for each child who received multiple tests between 2018-2022. If a child received more than one test in the five-year period, only one test was counted. The process of selecting which test to use for analysis when a child had multiple tests within the five-year period follows the CLPPP method to de-duplicate records. This method retains the most

accurate test available for analysis. If a child had multiple tests over the five-year period, the following criteria were used to select the most accurate test:

1. The highest venous blood lead level (BLL), if available.
2. If no venous test was performed during the five-year period, the highest BLL from a capillary test was used.
3. If the only test results were of an unknown sample type, then the highest of these results was used.

The child's address at the time of the selected test was used to assign the child's MCD (i.e. community) of residence.

Case Definition

In May 2022, Michigan changed the blood lead reference value (BLRV) from ≥5 µg/dL to ≥3.5 µg/dL following the CDC's updating of its BLRV the prior year.[4,5] This analysis defined a case as a child under age 6 with at least one EBLL at ≥3.5 µg/dL during 2018-2022.

Risk Factors for Lead Exposure: Age of Housing and Poverty

Children experiencing poverty and/or living in old housing may experience an increased risk of lead exposure from lead paint and other sources.[3] Furthermore, the families of children experiencing poverty have fewer resources to remove the child from exposure and address exposure once it occurs. To account for differences in vulnerability, the model modified community-level incidence rates with community-level measures of childhood poverty and older housing before comparing to the state rate.

The most common source of lead exposure is from deteriorating lead paint in homes built before the lead paint ban in 1978.[6] In 2021, 62.5% of Michigan's 4.5 million housing units were built before 1980[*], and a third of these were built before 1950.[7] This model includes housing stock as a proxy for lead paint and dust exposure among children in a community.

The U.S. Census Bureau estimates inflation-modified minimum income levels called 'poverty thresholds' while considering family size. Dividing a family's income by their corresponding poverty threshold determines their poverty income ratio (PIR) (PIR = annual income/ poverty threshold). For example, if a family's PIR is below 1.0, it means their income is below the poverty threshold. A PIR of 1.5 as a threshold for socioeconomic vulnerability was chosen for the purposes of this analysis to mirror that used in the CDC's Social Vulnerability Index and is meant to account for the fact that families living above the poverty threshold still experience increased socioeconomic vulnerability. [8,9] Housing and poverty metrics were sourced from the Five-Year 2021 American Community Survey.[7]

[*] The Census reports the year a structure was built by decade, with 'built before 1980' being the closest approximation to 'built before 1978.'

Calculation and Comparison of Incidence Rates and Bounds

The steps below summarize the analyses constituting this model.

1. Identify incident cases between 2018-2022 and calculate the five-year incidence rate and confidence intervals for each MCD and Michigan.
2. Calculate housing and poverty ratios for each MCD.
3. Calculate modified incidence rates for each MCD.
4. Calculate modified upper and lower bounds for each MCD.
5. Compare each MCD's modified lower bound with the state's upper confidence interval.
6. Compile a list of high-risk MCDs.

Step 1: Identify incident cases between 2018-2022 and calculate the five-year incidence rate and confidence intervals for each MCD and Michigan.

The Incidence Rate (IR) for EBLL cases per 1,000 children tested under the age of 6 for each MCD and Michigan between 2018-2022 and the associated confidence intervals are calculated as follows:

IR = Numerator / Denominator * 1000

Numerator: The number of cases defined as having an elevated blood lead level during the five-year period in the MCD and Michigan.

Denominator: The total number of children under age 6 years tested for lead exposure over the five-year period in the MCD and Michigan. Each child is counted only once within this timeframe.

The bounds of the upper and lower 95% confidence levels around the IR were calculated according to the following equation:

Upper/Lower Confidence Interval Bound: ((IR ± 1.96) * √(IR * (1 – IR) / # Tested)) * 1,000

Step 2: Calculate housing and poverty ratios for each MCD.

The percent of all housing units built before 1980 was calculated for each MCD and for the state. The corresponding housing ratio for each MCD was then calculated by dividing this pre-1980 percent for the MCD by the pre-1980 percent for the state. The percentage of children under age 6 years living in families with a PIR of less than 1.5 was calculated for each MCD and for the state. MCD-level poverty ratios were subsequently calculated by dividing the MCD-level percent by the state percent.

For example, Highland Park's ratios are calculated as follows:

%Pre-1980 Homes in Highland Park/%Pre-1980 Homes in Michigan: 84.2%/63.5% = 1.3

%PIR 1.5 in Highland Park/%PIR 1.5 in Michigan: 75.8%/31.9%=2.4.[†]

[†] Estimates are downloaded from the ACS 5-Year 2021 Tables B25034 (Housing) and B17024 (Poverty).

Step 3: Calculate modified incidence rates for each MCD.

The modified incidence rate for each MCD was calculated by multiplying the five-year incidence rate by both the housing ratio and the poverty ratio as shown below:

Modified incidence rate = IR * poverty ratio * housing ratio

For example, Highland Park's incidence rate of 224 EBLLs per 1,000 children tested was modified using the ratios calculated in Step 2:

224 * 84.2/63.5 * 75.8/31.9 = 705.8

Step 4: Calculate modified upper and lower bounds for each MCD.

The confidence intervals for each MCD IR were modified in the same way as the IR itself to generate modified upper and lower bounds:

Modified Lower/Upper Bound = Lower/Upper Confidence Interval Bound * poverty ratio * housing ratio

Step 5: Compare each MCD's modified lower bound with the state's upper confidence interval.

The modified lower bound for each MCD was assessed for whether it was higher or lower than the upper confidence interval bound for the state IR.

Step 6: Compile a list of high-risk MCDs.

Each community whose modified lower bound was higher than the upper confidence interval bound for the state IR was classified as a high-risk community with regards to lead exposure.

Results and Discussion

During the five-year period, among the 1,520 MCDs in Michigan, 1,174 (77%) experienced at least one confirmed case of an EBLL ≥3.5 µg/dL. Three hundred and forty-six MCDs (23%) had zero EBLLs reported between 2018 and 2022.

Running the model with this case definition resulted in 82 MCDs (5%) being identified as high-risk communities for child lead exposure in Michigan. These 82 communities are listed in Table 1.

The unmodified five-year case incidence rate (IR) ranged widely across the communities from 224 cases per 1,000 children tested in Highland Park (city) to 33 in Inkster (city). Modifying the IRs to account for child poverty and older housing stock led to noteworthy shifts in relative rankings among the 82 communities. For example, Hudson (city), Dowagiac (city) and Ionia (city), all of which are within the top 10 communities when ranked on unmodified IRs, moved further down the list post-modification, with Saginaw (city), Morenci (city) and Detroit (city) entering the highest-risk 10 communities in their place.

The analytical approach described here should be repeated as testing rates increase under the universal testing paradigm in future years. This would help reduce any statistical instability arising from small testing and/or case numbers included in the present analysis, which may

have increased the magnitude of the 95% confidence interval and resulted in a community's modified lower bound not exceeding the state rate's upper bound — despite the community's rate itself being higher than the state's rate.

Table 1: High-Risk MCDs by Five-year Modified Incidence Rates (with EBLL of 3.5 µg/dL per 1,000 tested children) that Statistically Exceeded[A] Michigan's Incidence Rate, 2018-2022.[B]

MCD Name	County	MCD 5-year Incidence Rate per 1,000 tested	State 5-year EBLL Incidence Rate per 1,000 tested	State Upper Bound	MCD Modified Lower Bound	MCD Modified Incidence Rate per 1,000 tested
Highland Park (city)	Wayne	224	51	52	610	706
Muskegon Heights (city)	Muskegon	168	51	52	479	555
Jackson (city)	Jackson	185	51	52	450	488
Galien (township)	Berrien	180	51	52	197	483
Albion (city)	Calhoun	158	51	52	382	481
Evart (city)	Osceola	169	51	52	280	458
Muskegon (city)	Muskegon	190	51	52	362	393
Scottville (city)	Mason	133	51	52	171	380
Medina (township)	Lenawee	116	51	52	64	363
Saginaw (city)	Saginaw	100	51	52	324	361
Morenci (city)	Lenawee	142	51	52	185	348
Detroit (city)	Wayne	113	51	52	325	333
Homer (township)	Calhoun	154	51	52	194	330
Dowagiac (city)	Cass	164	51	52	241	318
Curtis (township)	Alcona	158	51	52	83	313
Hamtramck (city)	Wayne	89	51	52	272	305
Hudson (city)	Lenawee	172	51	52	199	304
Ionia (city)	Ionia	149	51	52	232	300
River Rouge (city)	Wayne	88	51	52	216	293
Wright (township)	Hillsdale	140	51	52	150	293
Port Huron (city)	Saint Clair	136	51	52	248	276
Benton Harbor (city)	Berrien	81	51	52	174	232
Adrian (city)	Lenawee	117	51	52	176	214
Stanton (city)	Montcalm	135	51	52	66	213
Bad Axe (city)	Huron	68	51	52	83	207

Bay City (city)	Bay	87	51	52	171	203
Battle Creek (city)	Calhoun	110	51	52	178	197
Croswell (city)	Sanilac	100	51	52	80	194
Niles (city)	Berrien, Cass	79	51	52	138	192
Ithaca (city)	Gratiot	103	51	52	56	186
Three Rivers (city)	Saint Joseph	131	51	52	146	186
Hartford (city)	Van Buren	73	51	52	83	183
Lagrange (township)	Cass	100	51	52	79	180
Bronson (city)	Branch	82	51	52	59	177
Maple Valley (township)	Montcalm	163	51	52	86	172
Mount Morris (city)	Genesee	51	51	52	62	172
Ironwood (city)	Gogebic	88	51	52	97	171
Cato (township)	Montcalm	107	51	52	81	166
Lansing (city)	Clinton, Eaton, Ingham	85	51	52	153	166
Hillsdale (city)	Hillsdale	69	51	52	104	161
Owosso (city)	Shiawassee	97	51	52	128	157
Saint Louis (city)	Gratiot	82	51	52	78	157
Union (township)	Branch	74	51	52	58	155
Imlay City (city)	Lapeer	64	51	52	78	153
Flint (city)	Genesee	48	51	52	135	152
Ishpeming (city)	Marquette	84	51	52	85	152
Pokagon (township)	Cass	138	51	52	60	152
Gladstone (city)	Delta	90	51	52	73	151
Grand Rapids (city)	Kent	102	51	52	142	149
Colon (township)	Saint Joseph	100	51	52	61	148
Sturgis (city)	Saint Joseph	85	51	52	110	148
Escanaba (city)	Delta	68	51	52	100	147
Reed City (city)	Osceola	77	51	52	69	145
Kalamazoo (city)	Kalamazoo	89	51	52	129	143

Benton (township)	Berrien	41	51	52	97	142
Bridgeport (township)	Saginaw	76	51	52	98	140
Springfield (city)	Calhoun	57	51	52	86	140
Calumet (township)	Houghton	91	51	52	81	131
Coldwater (city)	Branch	110	51	52	93	126
Ludington (city)	Mason	84	51	52	89	125
Pontiac (city)	Oakland	55	51	52	109	124
Buena Vista (township)	Saginaw	55	51	52	81	122
Menominee (city)	Menominee	70	51	52	65	120
Wayne (city)	Wayne	49	51	52	85	120
Allegan (city)	Allegan	117	51	52	83	117
Inkster (city)	Wayne	33	51	52	87	116
Constantine (township)	Saint Joseph	123	51	52	68	108
Port Huron (township)	Saint Clair	74	51	52	77	108
Lansing (township)	Ingham	82	51	52	73	107
Paw Paw (township)	Van Buren	77	51	52	59	100
Mount Clemens (city)	Macomb	45	51	52	66	99
Summit (township)	Jackson	66	51	52	77	98
Leoni (township)	Jackson	81	51	52	71	93
Manistee (city)	Manistee	109	51	52	62	93
Belding (city)	Ionia	59	51	52	55	92
Eastpointe (city)	Macomb	43	51	52	72	91
Ecorse (city)	Wayne	45	51	52	60	90
Lapeer (city)	Lapeer	67	51	52	53	83
Greenville (city)	Montcalm	68	51	52	54	80
Monroe (city)	Monroe	50	51	52	54	77
Harper Woods (city)	Wayne	42	51	52	52	75
Lincoln Park (city)	Wayne	34	51	52	55	69

[A] “Statistically exceeded” means the community's lower bound is greater than Michigan's Upper bound. For example: Highland Park’s modified lower bound of 610 exceeds the state’s upper bound of 52.

[B] Data are current as of March 31, 2023.

Appendix

This analysis is a modified version of that developed by the Massachusetts Department of Public Health with the following adaptations:[10]

1. Case Definition Modification:

The Massachusetts model uses an EBLL case definition of ≥ 10 µg/dL for children aged 9-47 months. In contrast, the Michigan adaptation utilizes a broader definition by aligning with the CDC BLRV at ≥ 3.5 µg/dL for all children under 6 years old.[5]

2. Incidence Rate Denominator Modification:

The Massachusetts model calculates the incidence rate denominator by incorporating every test that satisfies the criteria per year, potentially counting a single child multiple times in the incidence rate. Conversely, the Michigan adaptation uses a *single* test per child across the entire five-year span, using criteria described in the Methods.

3. Population Income Ratio (PIR) Variation:

For the PIR used in the modification of the incidence rates to account for socioeconomic variability, the Massachusetts model employs a threshold of 200%. In contrast, the Michigan adaptation uses a PIR threshold of 150%.

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