Reductions in Blood Lead Level Screening During Peak COVID-19 Restrictions and Beyond

By

Meghan L. McCarthy

ScB, Brown University, 2019

MD/ScM Candidate, Warren Alpert Medical School of Brown University, 2024

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Date: __________ ____________________________________
Indra Neil Sarkar, PhD, MLIS
Thesis Advisor

Date: __________ ____________________________________
Mark R. Zonfrillo, MD, MSCE
Thesis Reader

Date: __________ ____________________________________
Michael Mello, MD, MPH
Director, Master of Science in Population Medicine

Approved by the Graduate Council

Date: __________ ____________________________________
Thomas A. Lewis
Dean of the Graduate School

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Introduction

Childhood lead poisoning is an important environmental health issue, and the widespread implementation of lead screening has led to major successes in improving public health. While the effect of lead on healthy development is dose-dependent, even low lead levels are associated with negative and irreversible long-term effects on cognition, learning, and behavior.[1,2] In 2021, the Centers for Disease Control and Prevention's (CDC's) standard for a blood lead reference value was further decreased from 5.0 to 3.5 μg/dL, representative of the fact that there is no 'safe' blood lead level, and that early identification and intervention is critical in reducing the long-term effects of neurotoxicity associated with lead poisoning.[3]

Universal lead screening is required for all children by law in Rhode Island (RI) with at least two blood lead screening tests on all children by three years of age. Children identified as having elevated lead levels (≥ 3.5 μg/dL) are tracked by the Healthy Homes and Lead Poisoning Prevention Program through the RI Department of Health (RIDOH) to coordinate efforts to reduce lead exposure and prevent further harm from lead exposure.[4]

Among the multitude of negative health effects on children associated with COVID-19 pandemic, an important one was the significant interruption in the provision of routine pediatric primary care. A national report by the CDC found a 34% reduction in the number of blood lead levels in the period of January 2020–May 2020 as compared to the same period during the previous year.[5] A significant source of lead exposure is in homes built before 1978, and so the significant increase in time children spent in their homes during the COVID-19 may have further exacerbated the issue, with children spending more time exposed to toxic lead without having the regular primary care visits to detect and intervene on lead exposure.[6]

Health information exchanges (HIEs) leverage information technology to facilitate the sharing of health data across hospitals, outpatient practices, pharmacies, and other entities across otherwise fragmented health systems. HIEs were developed as a method of quality-improvement to streamline communication of health information.[7,8] Though still limited by information gaps, confidentiality concerns, and other logistical constraints, they have been studied as potential helpful resources for school-nurses and in emergency room settings in pediatric populations.[9-12] Additionally, HIEs offer a wealth of information that can be leveraged to investigate important "real-world" population health questions.

In this study, we used a dataset extracted from RI's HIE to study trends in pediatric lead screening in the COVID-19 era. We hypothesized that the time periods of peak COVID-19-related restrictions would be associated with reduced BLL screening. We also predicted that there would be increased elevated lead levels during the catch-up periods following the initial COVID-19 restrictions.

Methods

Data source:

The Rhode Island Quality Institute (RIQI) operates RI's HIE "CurrentCare" and is the state-designated Regional Health Information Organization. CurrentCare contains electronic health data from 48 data-sharing partners, including electronic health records (EHRs) from all acute care hospitals in RI in addition data from numerous ambulatory practices, laboratory facilities, imaging centers, and pharmacies across the state. As of 2023, over 536,000 individuals have opted to share their health data with CurrentCare.

De-identified (expert-determined) data from CurrentCare were provided by RIQI for the study period January 2018 – December 2021 using the phenotype defined for the National COVID Cohort Collaborative (N3C).[13] This COVID-19 pediatric dataset contained lab-confirmed, suspected, and possible cases of COVID-19. These cases were demographically matched (on age group, sex, race, and ethnicity) to controls who tested negative or equivocal for COVID-19, at a ratio of 1:2 (cases to controls). These data were standardized to the Observational Medical Outcomes Partnership (OMOP) common data model.

Analysis and data visualization:

We used observational data from the COVID-19 pediatric dataset to investigate trends in lead screening in RI between 2019 and 2021. We utilized ATLAS, a free, publicly available, web-based analytics platform that was created by the Observational Health Data Sciences and Informatics (OHDSI) community to facilitate descriptive analysis of patient-level EHR data.[14] First, we created

Concept Sets extracting variables of interest using labels within the OMOP standard data format, using Logical Observation Identifiers Names and Codes (LOINC) for laboratory data. LOINCs included ("Lead [Mass/Volume] in Venous Blood", concept ID: 46236017 and "Lead [Mass/Volume] in Blood", concept ID: 3020331). This Concept Set was then applied to the dataset to create a cohort of individuals with one of the LOINCs attached to their health data during the specified time period (January 2019 through December 2021). Finally, we used the 'characterization' feature in OHDSI ATLAS to stratify the cohorts by demographic variables and timepoints of interest. To identify elevated BLLs, we queried all lab findings (with the above concept set via LOINCs) which had results greater than 3.5 µg/dL. Once counts were extracted in aggregate, we analyzed temporal trends and demographic associations of BLL screening and rates of abnormal levels using descriptive statistics and graphic visualizations.

Results

Study population:

Table 1 shows demographic factors of the study population of the entire pediatric dataset and those with at least one BLL recorded during 2019-2021. Almost all (97.7%) of those in the BLL screening group were in the 0–3-year-old or 4-9-year-old age group. The proportion of female individuals was almost exactly half for both the overall population and BLL group. Nearly one-third (28.7% overall, 30.1% of those in BLL group) identified as Hispanic/Latinx, which is higher than the overall RI population of 17.6% according to Census data.[15]

Lead screening trends:

Figure 1 compares monthly counts of BLLs in 2019-2021. During 2019, there were an average of 230 BLLs per month. In April and May 2020, there was a precipitous drop in overall BLLs to 60 in April 2020 and 106 in May 2020, representing initial periods of shelter-in-place in response to the COVID-19 pandemic.

The percent change in total BLLs conducted in each quarter of 2019-2021 is shown in Table 2. While counts of BLLs briefly returned to near 2019 levels in quarter 3 of 2020 (6% difference) and quarter 1 of 2021 (0.2% difference), they have otherwise remained considerably lower (range % difference compared to 2019: 17.1 to 38.6%).

Trends in elevated BLLs:

While the total number of BLL screenings decreased over 2019-2021, the proportion of levels detected above the CDC standard of 3.5 µg/dL increased (Figure 2). Between 2019-2021, the rates of elevated BLL were 3.25%, 5.75% and 5.09% respectively. Comparing 2019 to 2020, the rate ratio of abnormal was 1.76. Comparing 2019 to 2021, the rate ratio of abnormal BLL was 1.55.

Discussion

In this study, we compared levels of BLLs in the years 2019-2021 and found that BLL screening was and continues to be dramatically affected by the restrictions put in place due to the COVID-19 pandemic. Only for one month in the study period (March 2021) did BLL counts exceed any month in the pre-pandemic period of 2019 and January through March 2020. This suggests that there are significant deficiencies in lead screening that likely remained overall unresolved. Detection of elevated BLL through lead screening requires timely intervention and follow-up, which was likely delayed or missed altogether throughout the COVID-19 pandemic.

The overall prevalence of lead poisoning in RI (defined by the previous standard of 5 µg/dL or greater) was estimated to be 2.9% in 2018 by RIDOH.[16] In this study, we found that the annual rate of abnormal BLLs increased year-over-year between 2019-2021. Importantly, these rates do not represent incidence, as some abnormal levels may be confirmatory or surveillance tests for the same individual in the database. However, this is consistent with other research that also showed increased proportion of elevated lead levels during periods of peak COVID-19 restrictions.[17] We hypothesize several potential reasons for increasing rates of abnormal lead levels. First, lead poisoning is most commonly due to exposure from deteriorating lead paint in homes built before 1978, when the use of lead paint was banned for residential properties. Up to 80% of housing stock in Rhode Island was built before 1978.[18] Due to school and daycare closures during the early COVID-19 pandemic, children spent more time in their homes, potentially leading to higher exposure to lead. It is also possible that those at higher risk are more likely to have been prioritized by their medical providers for BLL screening due to increased risk factors. Nonetheless, the rise in abnormal levels in the context of overall decreased BLL screening is highly concerning and requires further investigation.

As mandated by state law, lead screening in RI most often occurs between the age of one and three years old.[16] These ages represent an especially important period for routine primary care, namely due to the provision of important vaccinations and developmental screenings. Disruptions in lead screening in the COVID-19 era is one aspect of a broader issue in the disruption of preventive and primary care for pediatric populations. A recent CDC report found that coverage with four vaccines (Measles, Mumps, and Rubella/Polio/Diphtheria, Tetanus, and Pertussis/Varicella) among kindergarten children during the 2021–22 school year remained lower nationally than the two prior years, when children entering kindergarten would have received these vaccines prior to the COVID-19 pandemic. In almost all states, coverage with these four vaccines has declined since 2019.[19] This is consistent with other research that has demonstrated a drastic drop in vaccination uptake during initial period of the COVID-19 pandemic, and that these declining rates have persisted.[20]

The COVID-19 pandemic continues to expose and exacerbate significant inequities in pediatric health and healthcare access. Previous studies with geospatial analyses in RI showed that the greatest burden of lead poisoning occurs in neighborhoods with older housing structures and higher levels of poverty.[21] Many of these neighborhoods overlap with neighborhoods that suffered some of the greatest impacts of the COVID-19 pandemic in RI.[22] For example, the city of Central Falls has the highest rate of childhood poverty in Rhode Island (39.4%) with an incidence of first-time elevated BLL (>5 ug/dL, 2.7%), compared to the overall state average of 1.7%[18] Unfortunately, Central Falls was also among the hardest hit cities in RI by COVID-19, in terms of overall cases and severe disease requiring hospitalization and/or intensive care admission.[22,23] The impact of COVID-19 on the provision of routine primary care is another way that the pandemic is reinforcing existing health disparities.

Leveraging for HIE for population health research:

An additional aim of this study was to leverage the use of CurrentCare, RI's statewide HIE, to answer an important population health question for a pediatric population. HIEs have many advantages for population health research; they can provide a wealth of information to study population health due to large sample sizes and broad data sources. Recently, Ho *et al*. utilized CurrentCare's HIE data to study suicidality and mental healthcare utilization among unhoused populations in RI.[24] Ho *et al*.'s study is one example of how HIEs can be a useful tool to study trends over time for important public health issues that can otherwise be difficult to study, potentially making findings more generalizable than those of a single practice or healthcare entity. Given the relative rarity of many pediatric diseases and distinct challenges of pediatric clinical research, HIEs offer a unique opportunity for pediatric population health research as well.

Utilizing health information, however, requires careful attention to data security and de-identification, which can lead to barriers for its use in research. CurrentCare is currently an opt-in data sharing system, where patients must provide consent to share their health data, most often during an interaction with the healthcare system (e.g., at an ambulatory visit). This process makes it possible that those represented in CurrentCare may differ from the general population, such as increased representation of those with medical complexity due to more frequent contact with the healthcare system. A legislative change in 2021 will enable the change of CurrentCare's consent model to "opt-out" (where health data will be shared for all except for those who opt-out of the system). In addition, due to the rigorous de-identification of the dataset used for the study reported here, there were some important limitations of our analysis for this study. We were only able to analyze lead levels tested in aggregate, and we were not able to track individual-level patterns of lead screening nor determine whether individual tests were for screening or confirmatory purposes. Additionally, demographic data pertaining to race, insurance status, exact age (not age group), and geographic data (e.g., ZIP code) were unavailable to be analyzed. Future studies should investigate which populations are at most risk for missing routine lead screening to guide more targeted interventions and follow-up to resolve deficiencies in lead screening.

Conclusion

Since early 2020, BLL screening has decreased while the frequency of detected abnormal BLLs appears to have increased among children in RI. The reductions in BLL screening likely represents one outcome of the significant disruptions that continue to impact the provision of pediatric primary care nationally, which have not fully recovered from the initial effects of the pandemic in spring 2020. Leveraging HIE data can provide important insight into statewide trends of pediatric healthcare access and utilization.

Table 1: Demographics

	Overall Dataset	At least 1 BLL (2019-2021)
Age Group		
0-3 years	8,291 (36.3%)	2,874 (57.4%)
4-9 years	8,060 (35.3%)	2,012 (40.2%)
10-14 years	5,727 (25.1%)	104 (2.1%)
15-19 years	779 (3.4%)	13 (0.3%)
Sex		
Male	11,514 (50.4%)	2,511 (50.2%)
Female	11,343 (49.6%)	2,492 (49.8%)
Ethnicity		
Hispanic/Latinx	6,553 (28.7%)	1,519 (30.4%)
Not Hispanic/Latinx	14,180 (62.0%)	2,712 (54.2%)
Unknown	2,124 (9.3%)	772 (15.4%)
Total	45,714	5,003

Table 1 shows the breakdown of the age group, sex, and ethnicity of the entire dataset as well as the cohort defined by having at least 1 BLL registered in the EHR-extracted data. Race was not a variable available to be analyzed in the original dataset.

Figure 1:

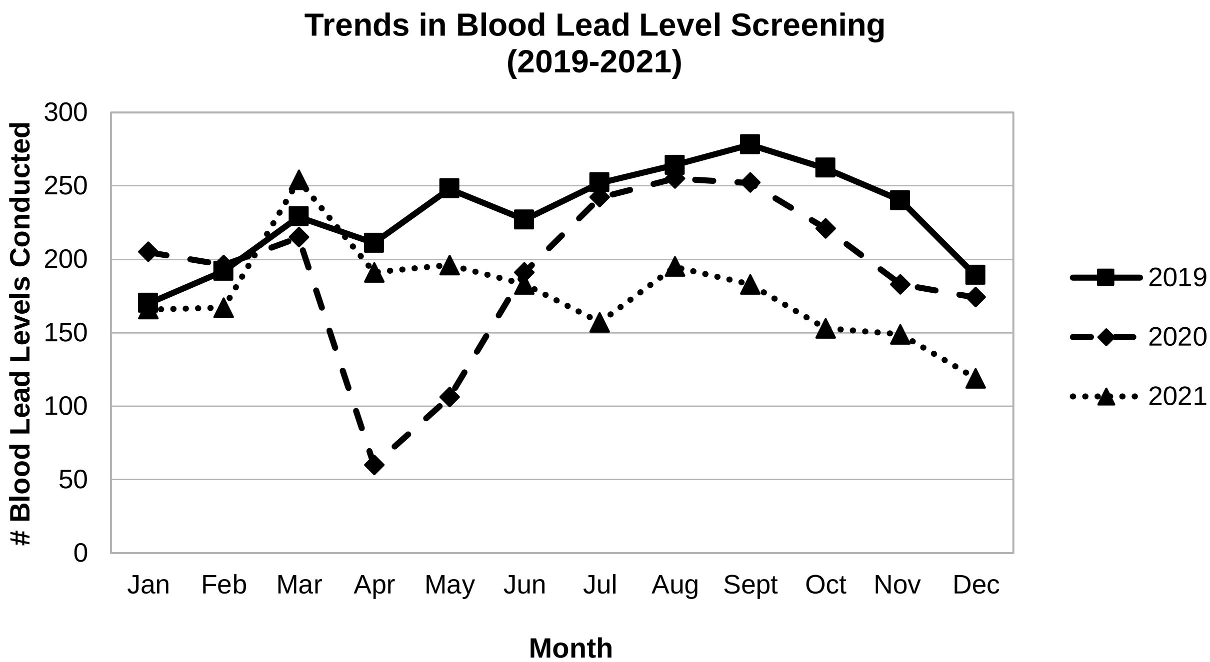

Figure 1 illustrates a comparison of monthly counts of BLL to demonstrate trends in overall counts during 2019, 2020, and 2021. After a drastic drop in BLLs during April 2020, BLLs per month rebounded somewhat, but never returned to pre-pandemic levels.

Table 2: Quarterly BLLs Between 2019-2021

	2019	**2020**	**2021**	**% change (2019 to 2020)**	**% change (2019 to 2021)**
Q1 (Jan-Mar)	588	629	587	7.0%	-0.17%
Q2 (Apr-Jun)	684	356	564	-48.0%	-17.5%
Q3 (Jul-Sep)	789	742	531	-6.0%	-32.7%
Q4 (Oct-Dec)	686	569	421	-17.1%	-38.6%
Totals	2,747	2,296	2,103	-30.6%	-23.4%

Table 2 compares quarterly BLLs between 2019 and 2021, with the last two columns showing the percentage change between 2019 (representing a pre-COVID 'control') and 2020 and 2021, respectively. The greatest % difference occurred in quarter 2 of 2019 and 2020, however, a significant % difference persisted late into the COVID period, notably in quarters 3 and 4 of 2021.

Figure 2:

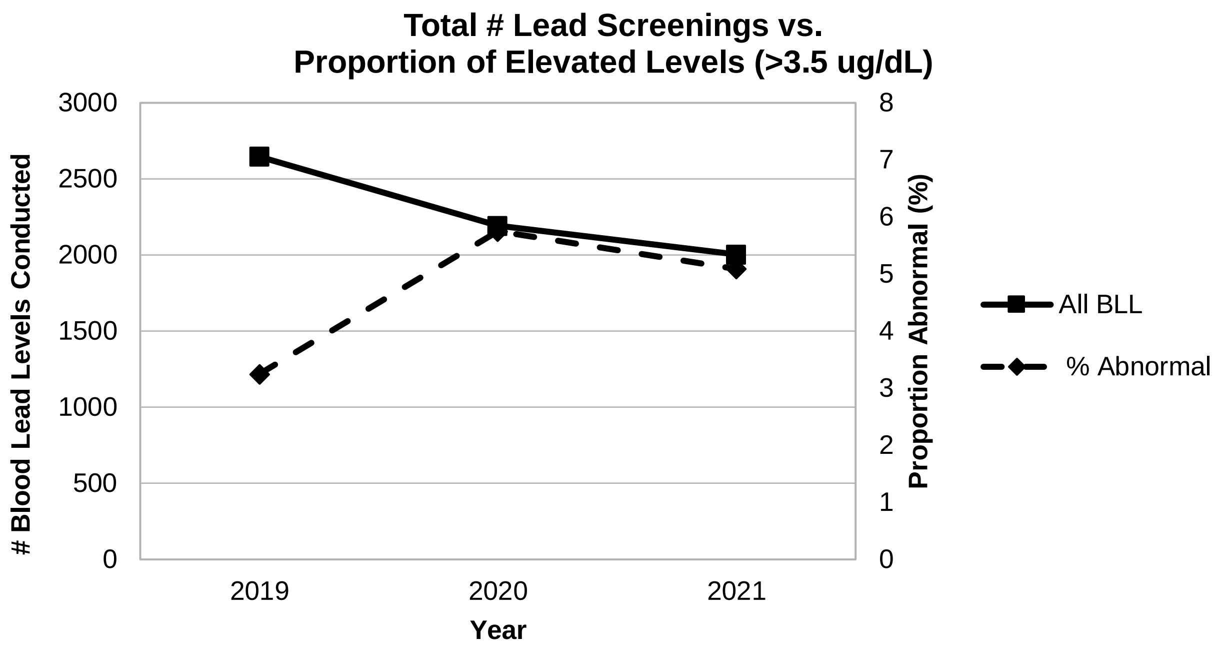

Figure 2 compares annual counts of BLL in 2019 through 2021 (primary y-axis) with the proportion of abnormal BLLs (secondary y-axis) during the same period. While overall numbers of BLL trended downward between 2019 and 2021, the proportion of abnormal BLLs increased in 2020 and 2021, compared to 2019.

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