Lead Poisoning in Milwaukee: A Medical and Public Health Update

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ABSTRACT

Introduction: Every year, children are poisoned with lead with irreversible effects. This exposure most often occurs in older housing built before 1978 with chipping paint from windowsills where children play and ingest the lead particulates. Exposure to lead can cause neurological and psychological dysfunction, among other health issues.

Objective: This quality improvement study aims to evaluate our knowledge of at-risk children through a public health approach by analyzing the current public health data and possible barriers to lead screening, testing follow-up, and identifying at-risk children.

Methods: We received data on lead-poisoned children and inspected properties from the City of Milwaukee Health Department. We analyzed each child's initial blood lead level, as well as follow-up tests recorded, ZIP code of residence, and family renter versus home ownership.

Results: Over 90% of children in the database had recorded follow-up blood lead testing following an initial elevated blood lead level. There was no difference in initial recorded blood lead levels between children with recorded follow-up blood lead levels and children without (21.40, SD = 11.26); t[1.17], *P* = 0.24). Most affected children were from economically disadvantaged ZIP codes (53206, 53208, 53215), and 94% lived in rented properties.

Conclusions: More work is needed to reduce lead in the environment and improve follow-up in affected children. ZIP code and rental data may indicate at-risk children. Although follow-up testing rates are high, the study revealed a wide range in lead levels with follow-up. Identifying at-risk children and reducing lead levels in children is vital to support health equity.

INTRODUCTION

Lead poisoning affects children across the United States and is especially prevalent in communities with older housing stock. Although lead poisoning and exposure have decreased in recent years, it remains a public health issue.[1-5] Lead exposure through ingestion typically is caused by chipping paint from windowsills where children play, as well as dust and lead in the soil and water.[2] Lead poisoning can present as neurologic dysfunction, psychological disorders, speech and language delay, anemia, or no symptoms. It can cause long-term problems for exposed children, such as kidney dysfunction, gout, peripheral neuropathy, neurocognitive defects, and developmental delay.[2,3] Levels over 3.5 µg/dl are described by the Centers for Disease Control and Prevention (CDC) as the current reference level for risk.[6] Despite the CDC reference level, no level of lead in the body is safe.[4,6,7]

With some of the state's highest lead poisoning rates, lead remains a severe problem in the city of Milwaukee. In 2021, nearly 6% of tested children under age 6 had levels greater than 3.5 µg/dL.[8] In Wisconsin, 4.3% of children have a detectable (>1.0 µg/dL) blood lead level (BLL) compared to the 1.9% national average.[9] Advancements towards less lead poisoning are underway, and some improvements of the environmental conditions already have been made.[10] Despite the advances, the need to bring lead exposures and levels down further provides a sense of urgency.[3,8,11]

The Wisconsin Department of Health Services (DHS), as of January 2024, recommends universal testing and that all children

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should obtain 2 lead tests by age 2. Children between ages 3 and 5 also should receive testing without a prior record.[11] Per Wis. Stat 254.11, children who have 2 venous levels between 15 mg/dl and 19.9 mg/dl more than 90 days apart or 1 venous BLL > 20 mg/dl qualify for a public health nurse referral for case management and monitoring as well as environmental investigations.[12,13] Additional measures are in place for all children with BLLs >5 mg/dl, including mailed educational materials and reminders about the importance of venous follow-up BLLs.[12] DHS also recommends local health department actions for any children with a BLL of 3.5 mg/dl.or above.[3] Local health departments rely heavily on local clinicians to perform screening and BLL testing on young children.[3]

The Medical College of Wisconsin (MCW) collaborates on a lead prevention project funded by Advancing a Healthier Wisconsin with City of Milwaukee Health Department (MHD), Children's Wisconsin, Children's Health Alliance of Wisconsin, and the Social Development Commission. This project prioritizes children and communities experiencing poverty, housing with lead hazards, challenges accessing health care, and environmental mitigation, racism, and discrimination. The goal of this project is to identify children with elevated BLLs and increase the connectedness between the clinical enterprise, MHD, community responses, and parental engagement following a positive lead test to mitigate ongoing lead exposures and decrease lead poisoning. Objectives include identifying children affected by lead in Milwaukee and the type of housing that families live in when exposed to lead.

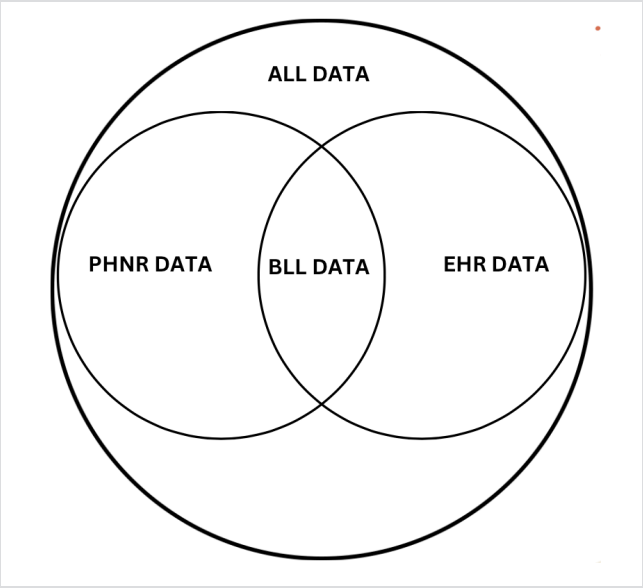
The project allows us to employ a quality improvement (QI) process to determine how to increase the number of children tested for lead within primary care clinics, improve follow-up, and support physicians' practices through a public health approach.

METHODS

A data use agreement was established between MHD and MCW to share data for research purposes. The data included: (1) blood lead test results, (2) nursing case management and monitoring encounters, and (3) home lead risk assessments. The data included a subset of children with elevated BLLs and who qualified for public health nurse referral case management and monitoring by having 2 levels between 15 μg/dl and 19.9 μg/dl more than 90 days apart or 1 level > 20 μg/dl (and some special cases where they accepted children with only 1 value >15 μg/dl) from January 2018 through December 2020. These dates apply to all data. The MCW Human Research Review Board approved the protocol.

The data received comprised 3 separate datasets: BLL data, public health nurse referrals, and environmental health referrals. Public health nurse referrals provide affected families with a public health nurse advocate for care coordination and resources. The environmental health referral dataset included children who had cases requiring home investigation. There was not necessarily exact overlap between the 3 datasets (Figure 1). The sample consisted of 367 children: the BLL dataset consisted of 281 children and included all BLLs recorded; the public health nurse referral dataset consisted of 205 children; and the environmental health referral dataset consisted of 285 children. Because data were extracted from an internal MHD database used during its transition from paper to electronic tracking, there was not direct overlap between demographic data found in the public health nurse referral dataset and BLL data. For this reason, we did not analyze descriptive statistics of the children within the datasets.

Figure 1. Venn Diagram of Data Overlaps



Abbreviations: PHNR, public health nurse referral; BLL, blood lead level; EHR, environmental health referral.

Some children were included in BLL data only (n = 56), PHNR plus BLL (n = 24), EHR plus BLL (n = 222), and some were included in all 3 datasets (n = 179). There was total BLL data for 281 children. The PHNR dataset consisted of 205 children and the EHR dataset consisted of 285 children.

Follow-up testing from the BLL dataset was analyzed in Excel. Mean first-recorded (initial) BLLs for each child with multiple recorded BLLs and those with only 1 BLL were analyzed and compared using an unpaired *t* test. ZIP code data from the environmental health referral dataset for each child's address was analyzed. Some children had multiple environmental home inspections performed at the same property. Some families had inspections completed at the same property for multiple children, such as siblings. Additionally, some children moved to a different address where an inspection was completed and then moved back to the original address where further inspections were completed. To be consistent, each child was analyzed individually regardless of relationship to different children. The first inspection performed at an address was counted. If multiple inspections were performed at the same address—even if they moved back to the original address after having moved away—they were not counted. Moving to a new address was counted as a new inspection. Per DHS, environmental home inspections continue at a new address if BLL is still elevated.[13] Property

Table. Comparison of Initial Blood Lead Levels (BLL) in Children (N = 281) Who Had Multiple Recorded BLLs and Children With Only One Recorded BLL

	Children With Multiple Recorded BLLs (N = 257)	Children With 1 Recorded BLL (n = 24)
Mean Initial BLL	25.3 µg/dL	21.4 µg/dL
Median Initial BLL	21.2 µg/dL	17.2 µg/dL
Maximum BLL	184.0 µg/dL	70.0 µg/dL
Minimum BLL	1.0 µg/dL	15.0 µg/dL 70.0 µg/dL
Total Children n (%)	257 (91.5)	24 (8.5)

ownership was determined by comparing the affected child's last name to the owner's name and came from the environmental health referral dataset. Child last names that were the same as the property owner's name were counted as ownership, whereas property owner names that were a limited liability company (LLC) or different from child names were counted as rented property. Although this novel method has limitations, without more detailed property ownership data and with the LLCs in the Milwaukee area owning many properties included in the dataset, comparing last names was used as a surrogate for home ownership information. A chi-square test was done to compare owned versus rented properties.

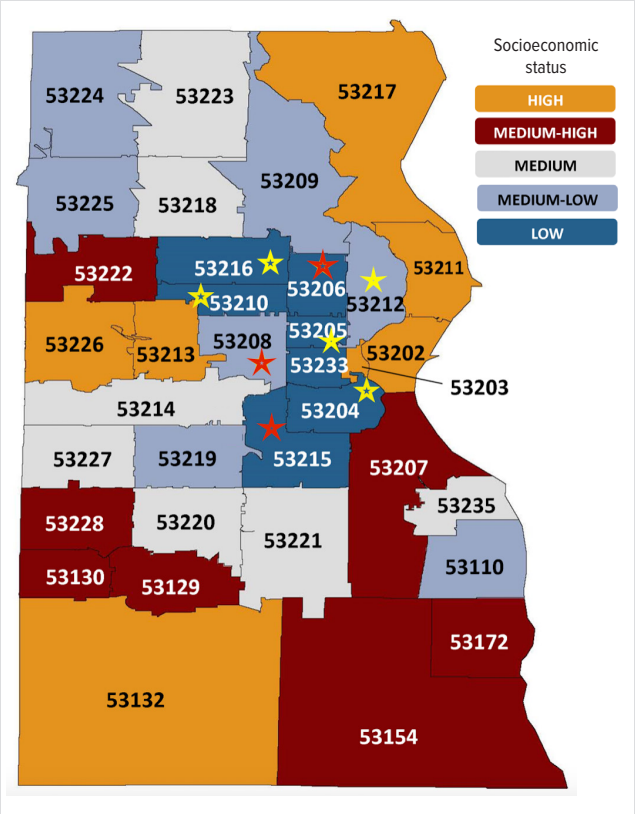
RESULTS

The dataset included 367 individual children. Out of 281 children with BLL data, 8.5% of had only 1recorded BLL (Table). There was no significant difference in initial BLL between the children who had multiple BLLs (25.33, SD = 16.06) and the children who only had 1 BLL in the dataset (21.40, SD = 11.26); t[1.17], $P = 0.24$). ZIP codes most affected were 53208 and 53206, making up just over 28% of the case-managed children (Figure 2). Out of 316 home inspection referrals in the dataset, 19 cases (6%) were individually owned, with the remaining 297 cases appearing to be rented (chi-square = 244, 1 degrees of freedom [DF]; 2-tailed P value ≤ 0.0001) based on previously described criteria.

DISCUSSION

Lead poisoning disproportionately affects historically marginalized and vulnerable populations. Previous studies suggest minority populations are disproportionately affected by lead—even beginning in utero.[14,15] Additionally, in this study, most children with an elevated BLLs are from historically underserved and economically disadvantaged ZIP codes (53208, 53206, 53215), consistent with previous data.[16-18] Being Black or African American has been shown to be the most important risk factor, second only to living in a pre-1950s house – even when controlling for all other factors, such as housing quality, poverty, and education.[14] Identifying as Black or African American and experiencing such a disproportionate amount of lead poisoning is likely a result of environmental racism, where Black and African American people in Milwaukee were forced into poor quality housing as the result

Figure 2. ZIP Codes of Public Health Lead Case Managed Children Categorized by Socioeconomic Status Using Education and Income Criteria per ZIP Code



ZIP code data was analyzed from 389 opened electronic health referral cases. Red stars indicate the highest numbers of public health lead case managed children (53208, 64 children total; 53206, 49 children total; 53215, 48 children total). Yellow stars indicate other high rates of case managed children (53210, 44 children total; 53204, 34 children total; 53212, 39 children total; 53216, 22 children total; 53205, 20 children total). Remaining children were from ZIP codes across Milwaukee County (from greatest to least number of cases: 53209, 53218, 53223, 53224, 53207, 53225, 53202, 53221, 53222, 53233, 53219). Map used with permission, courtesy of Health Compass Milwaukee.

of redlining in the 1930s and later, making Milwaukee one of the most segregated cities in the United States.[19,20] Our findings may reflect the enduring negative effects of segregation and redlining, as has been demonstrated in other disease states.[21-23] This puts Black or African American individuals in Milwaukee at continuous risk for and suffering from lead poisoning by living in the poor-quality housing in these ZIP codes.

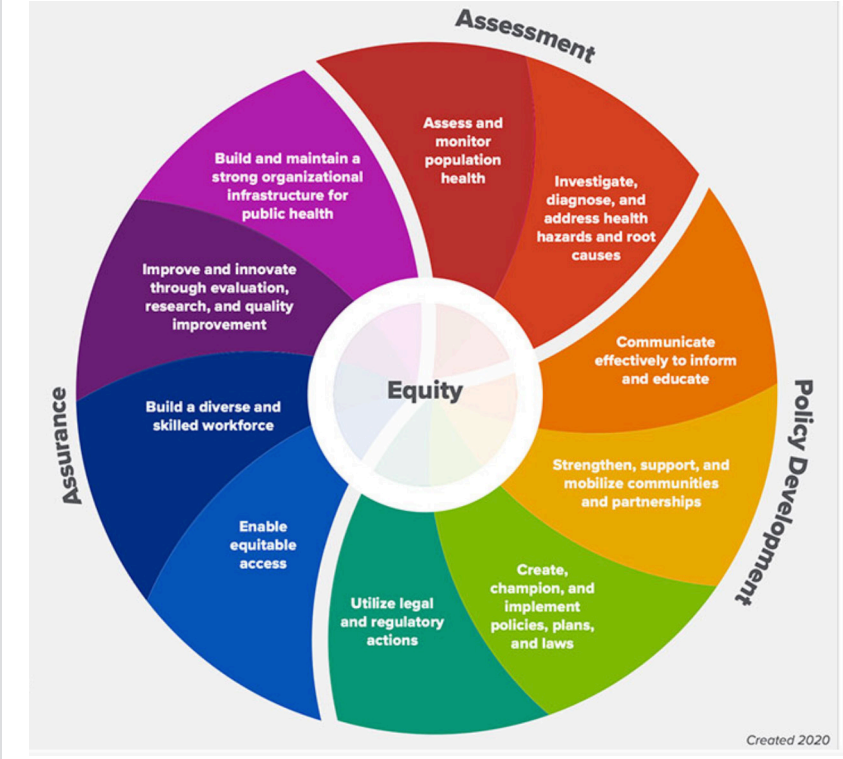
Multiple efforts are being made to monitor children exposed to lead. Over 90% of eligible children with an elevated BLL who received a public health nurse referral participated in public health nurse case management and monitoring care. Despite these successes, future efforts should seek to understand more about families who do not engage in public health intervention after referral.

Even with successful local public health follow-up and engagement, there continues to be a need to move towards primary prevention through home lead abatement. Evidence suggests that

social circumstances may be a barrier to care for the individuals who do not have medical follow-up, such as lack of cell phones or regularly changing phone numbers, eviction, needing to move, and lack of transportation.[24,25] More collaborative engagement strategies are needed to connect clinicians, families, and public health. One possible strategy could be equipping clinicians to provide public health mitigation measures, such as cleaning supply kits.[26,27] Clinicians can provide education on cleaning to parents, such as dusting windowsills, mopping floors, and eliminating carpets, which can help reinforce public health teaching.

To improve access to lead testing, we must better support the community by bringing lead safety materials and screening to community events. A combination of clinical focus, community response including landlord participation, and public health leadership to ensure safe environments could bring levels down more for the entire community. Although we have succeeded in trending towards lower BLLs and maintaining follow-up in most patients, there is room for improvement.

Figure 3. Essential Public Health Services per American Public Health Association[29]



A more equitable and socially just housing environment also is needed to protect future children from lead poisoning. Federal law mandates tenants in rented properties and those who buy a home need to be informed of lead hazards in any pre-1978 home.[28] However, almost all children with an elevated BLL live in rented properties, likely because they are the most affordable options. This is a key finding for clinicians. If most affected children are in rented homes, that may be a valuable demographic question to discuss with families to determine if they should be lead tested. Inquiring about rented versus owned properties is yet to be included on lead intake forms to determine lead screening in children.[11] A better understanding of living situations may provide further insight into lead poisoning risk.

More work is needed to achieve equity regarding housing stock, health care, and lead poisoning screening and treatment. The American Public Health Association has identified 10 essential services necessary to strengthen the public health system (Figure 3).[29] To achieve the goal of a lead-free Milwaukee, we first must assess the problem of lead poisoning. This includes continuing research into root causes, such as ZIP code data, property ownership data, and other risk factors. Second, policy development must support the goal of eliminating lead and its effects. This includes strengthening partnerships between local health departments, health care professionals, and property owners, ensuring funds are available for remodeling and infrastructure to house families who are removed from housing for abatement to take place, and requiring that all apartment complexes are lead-free. Lastly, researchers and public health officials must continue to assess and reevaluate lead and its effect in the community for new or persistent inequities.

Of course, these processes are not without unintended consequences and limitations. Funding for lead abatement, often paid by government grants, is inadequate. Residents may be evicted or need to find other housing while abatement occurs, which may not be affordable. Landlords may be unwilling or unable to renovate their complexes without significant supportive funding. Additionally, cleaning products and time spent on cleaning education in the clinical setting requires resources and takes up valuable and constrained clinician time. Thus, lead education and abatement require a significant increase in multimodal funding to eliminate the problem.

Limitations

A major limitation of this study is that the dataset comprised 3 individual datasets without exact overlap between the children, making it difficult to extrapolate which children received which services.

An additional limitation was determining rented versus owned properties. Because these data were not recorded, we used the child's last name and compared it to the owner's last name to determine property ownership. Most properties determined to be

rented were LLCs or names that repeated on multiple properties, but it is possible that the child's last name and parent/guardian's last name did not match and were counted in rented properties. However, because 93% of Blacks/African American residents in the city of Milwaukee reside in rented homes, the assessments are likely fairly accurate.[30]

Furthermore, the data set only included those who were referred for public health nurse case management and monitoring services, rather than all children who tested positive for lead. Similarly, blood lead tests from previous or future years may have been included in the dataset if they were related to a child referred for case management and monitoring during 2018-2020.

Lastly, public health relies on clinicians to order and perform blood lead testing, for which clinical practices differ. It is unknown what additional clinical follow-up children received and if differences in BLLs were a result of clinical protocols. This study examined only public health data.

CONCLUSIONS

A partnership of clinicians, public health, and community leaders is needed to decrease BLL more quickly and effectively in children. Understanding the community at-risk, eg, renters in particular ZIP codes, may help clinicians to understand risk and target lead screening to children most likely to be affected. Continued efforts should promote collaboration between clinical, community, and public health sectors. Lead poisoning is 100% preventable, and no measurable BLL is safe. We must advance our efforts to create a more just and equitable environment.

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