

# Chapter 15


## Using Geographic Information Systems to Map Lead Contamination in York City, Pennsylvania: Real-World Problem for Project-Based Learning

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### ABSTRACT

*Using elevated blood lead data and structure data, this research engages undergraduate geographic information systems (GIS) students to apply mapping and spatial analysis to investigate spatial patterns of lead contamination and identify the hotspots through spatial mapping and other analytical outputs at York College of Pennsylvania. It revealed that the highest EBLLs occurred among male Black children. The GIS visualization highlights correlations between the age of residential structures, elevated blood lead levels (EBLL) in children, and demographic factors. The results are used to educate policymakers, healthcare workers, landlords, and the general public about this critical public health issue. Conducted in a project-based service-learning module, students benefit by working with a real-world problem where they practice critical and analytical thinking, design solutions, and communicate them via community outreach and engagement. Such a learning experience helps the college and community partner via the Center for Community Engagement (CCE) Urban Collaborative.*

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## INTRODUCTION

Lead poisoning remains an ongoing public health challenge. Childhood lead contamination has extensive adverse health effects and continues to be a persistent risk affecting millions of children worldwide and impacting local communities in American cities (Caballero-Gomez et al., 2022; Ettinger, 2022; Fabolude et al., 2024; Lanphear et al., 2024). Research on lead poisoning primarily focuses on large American cities such as Buffalo, New York, Milwaukee, Wisconsin, and Cleveland; small cities located on the Rust Belt have been excluded and inadequately studied. The City of York, located in south-central Pennsylvania, represents such places because of its many past industrial activities during the 19th and early 20th centuries. As of the 2023 census, York City has a population of 44,800 residents. It has had a modest population growth over the last two decades, though it is below its peak population of nearly 60,000 in 1950.

This study will shed light on the persistent issue of lead poisoning in small Rust Belt cities and fulfill the need for more targeted research to educate local communities and develop effective interventions and policies tailored to the unique challenges of local communities. The Urban Collaborative at York College of Pennsylvania's (YCP) Center for Community Engagement (CCE) is interested in studying the “wicked problem” (Rittel & Webber, 1973) and its impact on the local populations in York.

The Urban Collaborative is a donor-supported initiative within YCP's CCE to increase safe and affordable housing availability in York. Lisa Fast, the founder, felt compelled to begin this work when she started her work with YCP (Urban Collaborative, n.d.). As she began to explore purchasing property near the campus, she was distressed to find that a large number of residences in the city, particularly those located in redlined neighborhoods, were lacking basic features, such as functioning plumbing, and contained hazards that made them unsafe (Urban Collaborative, n.d.). Despite these shortcomings, the homes in the area remain in high demand due to overall housing shortages. This leaves many neighborhoods in the area at risk for gentrification.

One of the primary methods of support that the Urban Collaborative utilizes to address these issues within the community is to engage students and faculty from various disciplines in project-based research that tangibly supports an improved quality of life in York. This chapter examines a community service project within an introductory-level geographic information systems (GIS) college class, focusing on its spatial methodology (Banks et al., 2024). The project involves GIS mapping childhood lead exposure occurrences in York, as reported by the City of York Bureau of Health.

## LITERATURE REVIEW

Lead is a naturally occurring but toxic metal that has been used in paints, gasoline, pipes for transportation of drinking water, soldering cans for food, insecticides, and other common goods throughout history (Lanphear et al., 2024). In the United States, the first records of lead-based paint production date back to the early 1800s in Philadelphia (Houck, 2024a). By the late 1800s, the National Lead Company was a major producer and seller of lead products throughout the United States. The most common methods of becoming exposed to lead absorption are ingestion and inhalation (Lanphear et al., 2024). Lockhart Gibson, an American clinician, linked lead-based paint to neurotoxicity in 1904; however, legislation

banning its use in paints was not enacted until the 1970s, with national bans going into effect for paint in 1978 and public water systems in 1986 (Houck, 2024a).

Before 1978, lead-based paint was the standard for painting walls, windowsills, and trims and was heavily advertised as a healthy option for homes and families from the 1920s to the 1970s despite evidence of its adverse health effects (Houck, 2024b). Most homes in York were built prior to 1978 (Hullinger, 2021). Homes built in or before 1978 predate lead paint restrictions and often contain lead contaminants that endanger the children in these homes (City of York, Pennsylvania, n.d.). As reported in the *York Dispatch*, of the approximately 18,000 structures in the city, 70% are identified as residential housing; and 84% of those structures were built before 1978 (Hullinger, 2021). Most of these homes still contain elevated levels of lead.

Although lead-based paint was widely used in all communities, it is well documented that impoverished communities of color were historically, and remain, disproportionately exposed to lead due to redlining (Houck, 2024b). Redlining, the practice of denying financial services, such as home loans, to people of color to segregate communities, has confined many people who hold marginalized identities to deteriorated homes and areas of concentrated poverty (Karp, 2023). The term redlining comes from a literal practice of color-coding maps for lenders to illustrate where loans should and should not be granted for different races (Karp, 2023). Areas coded as red were considered “hazardous” (Karp, 2023, p. 432) for various reasons that sometimes included real, physical hazards and blighted properties. However, some areas might be designated as hazardous simply because they were largely populated by people of color. Blue and green zones were considered “desirable” and “best,” while yellow zones were deemed “declining” (Karp, 2023, p. 432). Black and Hispanic families, in particular, have been, through open and covert policies, confined to these redlined areas for generations. Karp (2023) describes how areas with higher risks for lead exposure are often areas that were historically redlined, which contributes to the disproportionate elevated blood lead levels (EBLL) among Black children whose families do not have access to the same neighborhoods as their White counterparts.

According to the Pennsylvania Department of Health (n.d.), York has the highest confirmed EBLL for those under six in all of Pennsylvania, with 8.67% testing in the elevated range in 2021 (Walters, 2024). The *York Dispatch* reported that over 200 children in York are poisoned by lead each year (Hullinger, 2021). The World Health Organization (2023) indicates that the negative effects of lead exposure can be extreme and irreversible. Behavioral changes, neurological damage, and a variety of other negative health outcomes impacting all body systems have been documented (World Health Organization, 2023; U.S. EPA, 1989). Lead can cause serious health complications in children, such as brain damage, slowed growth, developmental delays, learning and behavior issues, attention and speech problems, and a variety of other health concerns that can impact children for the rest of their lives (Lead Free Promise Project, n.d.). Research has also linked childhood lead exposure to an increased risk of criminal behavior, including violent crime (Talayero et al., 2023) and antisociality, delinquency, and criminality in adulthood (Beckwith et al., 2021). Young children and pregnant women are particularly vulnerable to these adverse health impacts (Fabolude et al., 2024; Ortega et al., 2021).

Prior research has investigated an association between population-level exposure and criminal behaviors (Reyes, 2014) and individual levels using limited data to understand the magnitude of these associations (Talayero et al., 2023). These studies have established the understanding of later delinquent and long-term effects of antisocial adult behaviors.

To put the scale of this problem into a national context, York County, as a whole, has higher EBLL numbers than those seen in 2014 in Flint, Michigan, when residents' drinking water was contaminated with lead, a crisis that garnered national attention (Hullinger, 2021). Despite the alarming statistics, there has been no comprehensive systematic study on lead exposure among children in York, which underscores the critical research need for ongoing lead poisoning risk.

Federal guidelines require that all Medicaid-eligible children at higher risk for lead exposure be tested for lead at 12 and 24 months of age (U.S. Center for Disease Control and Prevention [CDC], 2024). These requirements do not extend to all children, and while the website does state that the best way to determine if a child has been exposed to lead is to have their blood tested, the guidelines leave discretion with parents and providers about when and if to test for lead if they are not enrolled in Medicaid (CDC, 2024). Currently, no mandated standard of care across medical practices ensures that all children are tested regularly. This can lead to under-reporting and allow families needing medical care and support to fall through the cracks (C. Legg Wood, K. Houck, & M. Howie, personal communication, August 29, 2024; C. Legg Wood, K. Houck, & M. Yingling, personal communication, July 17, 2024). WellSpan Health, one of the largest healthcare providers in south-central Pennsylvania, has enacted beneficial policies to test all children under their care for EBLL at nine months and 24 months using point-of-care tests that do not require additional appointments (Weaver, 2023). Not all facilities have the same procedures in place. There have been efforts to address this issue, but legislators in Pennsylvania have been unable to move policies forward that would advance these goals. In 2022, the Childhood Blood Lead Test Act was enacted, which “encouraged” healthcare providers to test all children for lead by age two. In 2023, there was a proposed amendment, Senate Bill 514, which sought to change “encourage” to “require” (S.B. 514, 2023-2024 Reg. Sess. (Pa. 2023)). This simple change would have required physicians to test all children at least once prior to their second birthday unless parents/guardians formally opted out. The bill was tabled and has yet to be reintroduced as of December 2024.

In addition to inadequate blood testing policies, there are also no policies ensuring regular inspections of rental units for lead. While federal law requires landlords to disclose if they are aware of lead sources within the residence, there is no policy requiring them to test residences for lead prior to renting them to tenants (C. Legg Wood, K. Houck, & M. Howie, personal communication, August 29, 2024; C. Legg Wood, K. Houck, & M. Yingling, personal communication, July 17, 2024; U.S. Housing and Urban Development, n.d.). The language in the housing and urban development policy leaves the door open for landlords by only requiring them to disclose “known information” rather than requiring testing at specific intervals (U.S. Housing and Urban Development, n.d.). This creates a loophole where landlords do not “know” about the lead if they do not conduct inspections. While property owners must provide a U.S. Environmental Protection Agency (EPA) -approved pamphlet (2024, June 10) to renters and new owners before ratification of a sale or lease contract for any residence built prior to 1978, they are not required to provide specific information or remediate or abate lead if they have not engaged in inspections. The pamphlet includes helpful information about the risks of lead exposure, resources for getting one’s child tested, information about home inspections, information about preventative measures that families can take to limit exposure risk, and other helpful guidance (EPA, 2024, June 10).

Despite many successes in childhood lead poisoning prevention in the United States, differing practices at medical facilities and the absence of lead rental inspection policies further exacerbate racial inequities created by redlining. Indeed, the *York Dispatch* reports that Black children are four times more likely, and Hispanic children are three times more likely, to be poisoned by lead than their White counterparts in York (Hullinger, 2021).

## Goals

Our goal with this work is to understand lead exposure hazards among children aged zero to 16 years old in York, the seat of York County in South-Central Pennsylvania. Leveraging the EBLL data from the City of York Bureau of Health and structural age data from York, this study employs GIS mapping and exploratory spatial analysis to uncover the insights. Additionally, the study aims to highlight correlations between the age of residential structures, EBLL in children, and demographic factors.

This project engages students enrolled in an introductory GIS course to analyze the distribution patterns of lead contamination and identify exposure hotspots within the city using a series of map products and analytical outputs. See the appendixes for student testimonials. The course is a designated High Impact Practice & Innovation (HIPI) course within the college's General Education Program, featuring project- or problem-based learning, community-based learning, interdisciplinary undergraduate research, and service-learning (York College of Pennsylvania Catalog, 2024). Its learning outcomes explicitly focus on data-based problem-solving, critical thinking, and spatial analytical skills, aligning seamlessly with the principles of project-based service learning.

In this community-anchored, project-based learning initiative, faculty plays a pivotal role as a facilitator, mentor, and coordinator, ensuring students achieve their learning objectives while providing meaningful service to the local community. As a GIS specialist, Dr. Pomeroy has provided GIS instructions for over two decades, bringing extensive expertise in applied GIS skills and project management. She has played a crucial role in designing PBL frameworks in her GIS courses that integrate geospatial competencies aligned with YCP's education outcomes and community-based problem-solving projects. Her previous work involved her Introductory GIS class students by providing them with a semi-independent, local community project-based research project where students applied their coursework to real-world issues through semi-independent research under faculty guidance and supervision. Additionally, the project completed incorporates community-based learning, fostering strong collaborative partnerships with local organizations. Identified through preliminary discussions with the CCE Director, the project was a suitable project-based service-learning project because of its authenticity of directly addresses a pressing public health concern the local community faces while equipping students with practical GIS skills (Anglistika, 2016; Romadlon & Sarwono, 2021).

By incorporating project-based service learning into this course, students are challenged to apply their learned GIS skills in real-world contexts, from research initiation to community outreach and engagement in educating the public, thus developing an improved understanding of complex real-world problems (Resch & Schrittester, 2023). The learning experience not only enhances students' GIS technical proficiency but also fosters partnerships with local organizations, paving the way for future project-based service-learning opportunities, which will continue to be facilitated by YCP's CCE and the college. The research findings on lead exposure hazards will offer tangible support to the residents of York City by providing clear, evidence-based information about the risks and health impacts of lead poisoning. The findings will help local residents understand how lead exposure occurs, identify common sources in their environment, and learn practical steps to reduce risks, such as proper testing for children and lead-safe home tips, raising awareness of the long-term effects of lead on children's development and health by emphasizing the importance of early detection and intervention. The mapping protocols developed will educate policymakers, healthcare workers, landlords, and the general public. By making this information accessible and actionable, the research empowers residents to advocate for healthier living conditions and engage in community-wide efforts to address and mitigate lead hazards.

## METHODOLOGY

This chapter employs GIS mapping and spatial analysis techniques to investigate the distribution of lead contamination in York City, Pennsylvania. York City was chosen for this study due to its partnership with the CCE's Urban Collaborative at YCP and its historical significance as an urban settlement shaped by industrial activities in the 19th and early 20th centuries. As a representative small urban community in the Rust Belt of the United States, York has a rich industrial history, including iron and steel manufacturing, the textile industry, paper and printing, and railroad and transportation equipment. These economic activities have significantly shaped the city's environmental landscape, making it a relevant site for studying lead contamination.

### Study Area and Unit of Analysis

The study utilizes the census tract as the primary unit of spatial analysis. A census tract is a small, relatively permanent statistical subdivision designated by the U.S. Census Bureau. The census tracts are effective operational analysis units commonly used in research, planning, and policy-making. Xue et al. (2023) demonstrated the effectiveness of a census tract as a generalized analysis scale in identifying high lead exposure locations in their case study in Michigan. York City, the largest municipality and county seat of York County in South-Central Pennsylvania, consists of 16 census tracts, providing a granular spatial framework for analyzing community-level lead exposure patterns. Using census tracts allows for data-driven, evidence-based decision-making that benefits a wide range of stakeholders such as the CCE, YCP, and local government agencies and community organizations.

### GIS and Spatial Analysis Techniques

GIS serves as a critical analytical tool in this research, offering an innovative approach to problem-solving and enabling students to develop technological skills while addressing real-world challenges through its advanced capabilities in data visualization and spatial analysis (Fitzpatrick, 2017; Romadlon et al., 2021). The study employs ArcGIS Pro Version 3.1 to georeference lead contamination data and integrate it with relevant geographic datasets. Several GIS techniques were applied, including:

- *Geoprocessing tools*: Pairwise clips, overlay analysis, and feature selection techniques (e.g., Select By Attributes, Make New Layer From Selected) are used to refine the dataset and perform necessary interim analyses.
- *Spatial alignment*: "Display XY" was used to spatially align blood lead test results with other geographic datasets.
- *Hot spot analysis*: The Getis-Ord  $G_i^*$  method is a spatial analysis tool in GIS that identifies hotspots and coldspots within a dataset. It measures spatial clustering by evaluating whether high or low values are clustered together in a given area. A high  $G_i^*$  value indicates a statistically significant hotspot. It was utilized to identify statistical clusters of lead contamination.
- *Proximity analysis*: Pairwise Clip is one of the Proximity Analyses of GIS, an advanced spatial analysis tool that performs a clipping operation between two feature classes while optimizing performance. This was used to evaluate the spatial relationship between lead contamination hotspots

and various land use categories, particularly residential areas, to determine potential exposure risks.

## **Project-Based Learning Approach**

The study adopts a project-based learning approach, combining academic learning outcomes with community service to enhance student learning and gain practical experience in GIS applications while addressing a real-world public health challenge. Project-based learning has been recognized for its effectiveness in fostering critical thinking, problem-solving, and technical skill development through hands-on experiences (Banks et al., 2023). By applying a spatial perspective in a real-world context, students gain practical experience in spatial analysis while contributing to data-driven, evidence-based solutions for mitigating lead exposure risks. This approach not only strengthens their technical competencies but also empowers them to make meaningful contributions toward creating healthier communities. With York City selected as the place-based learning activity, GIS allows students to connect to local communities and build critical thinking skills, as the study is rooted in the locality (Soucy et al., 2024). In turn, local community partners benefit from education-based and technologically rooted knowledge and solution suggestions.

## **Data Sources and Preparation**

The primary dataset was obtained through the Urban Collaborative's facilitation and provided by the City of York Bureau of Health. It covers the 2014 to 2023 time period and includes 9,469 blood lead test results using the graphite furnace method. Graphite furnace testing is a type of atomic absorption spectrometry (AAS) testing method for detecting and measuring trace amounts of lead in blood. It is a widely used testing method in public health research and clinical diagnostics to monitor lead exposure, particularly in children and at-risk populations.

The original datasets were anonymized for data privacy and protection of sensitive information. The key variables were recoded and pseudocoded to facilitate GIS mapping and spatial analysis. During the data preparation phase, records with null values were excluded to ensure data integrity. Additionally, supplemental datasets, including census tract shapefiles, administrative boundaries data files, streams, and other geographic feature files from the U.S. Census Bureau, York City Planning Office, and York County Open GIS Portal.

## **Significance of the Methodological Approach**

This study demonstrates how GIS technology can serve as an effective research tool for assessing spatial perspectives of childhood lead poisoning and exposure risk while fostering students' learning and community engagement. Such a comprehensive methodological approach highlights the value of GIS's cutting-edge technology. It equips students with essential GIS skills and fosters meaningful community engagement (EPA, 2024, November 7; Mane, 2024). Previous research by Akkus and Ozdenerol (2015) has already shown the effectiveness of GIS in studying childhood lead exposure, further supporting its role in advancing our understanding at the local scale, tackling lead poisoning issues, improving future lead testing, designing and implementing intervention programs, and promoting active community participation towards to a healthier locality (Callender et al., 2023; EPA, 2024, November 7). With continued

advancements in GIS technology, its role in environmental health research and policy development is expected to grow, leading to more effective and equitable solutions for reducing lead risks among children.

## **FINDINGS**

This section presents the key findings from the GIS-based mapping and spatial analysis conducted to assess lead exposure among children, from infants to age 16 in South-Central Pennsylvania. The analysis identified significant trends and revealed several notable insights into lead exposure in York City, providing a clearer understanding of the spatial distribution of EBLs among children and potential contributing factors.

### **Spatial Distribution of Lead Contamination in York**

GIS mapping of the EBL (interchangeably with EBL) data in York revealed lead amounts in blood among children aged from zero to 16 years old. Based on the dataset, the blood lead levels in York City range from a minimum of 0.1 ug/dL (micrograms per deciliter) to as high as 141 ug/dL from January 1, 2014, to December 31, 2023. According to the CDC (2012), a blood level of five ug/dL or higher concerns children. Later, the CDC lowered it to 3.5 ug/dL in 2021. It is stated that even lower levels can pose long-term health impacts. The U.S. Department of Health uses the same threshold value to initiate lead abatement. For this research project, an EBL of 5 ug/dL was used as the lowest threshold value to identify the spatial distribution patterns of lead hazard risks by census tract in York.

The following two maps generated by GIS highlight the spatial distribution patterns of EBL cases during the two time periods: 2014-2016, as seen in Figure 1, and 2020-2023, as seen in Figure 2. Figure 1 shows, from 2014-2016, 534 EBL cases were recorded at or above five ug/dL. That number increased to 613 cases between 2020-2023, which is a 14.79% increase. Additionally, the maximum recorded EBL value rose dramatically. The maps show that the highest detected EBL value rose from 51 ug/dL in 2014 to 141 ug/dL at the end of 2023—a 176.46% increase with York. They illustrate the intensification of lead contamination over time and underscore the growing need for public health intervention.

Figure 1. 2014-2016 tested Elevated Blood Lead Levels (EBLL) above five ug/dL by census tract

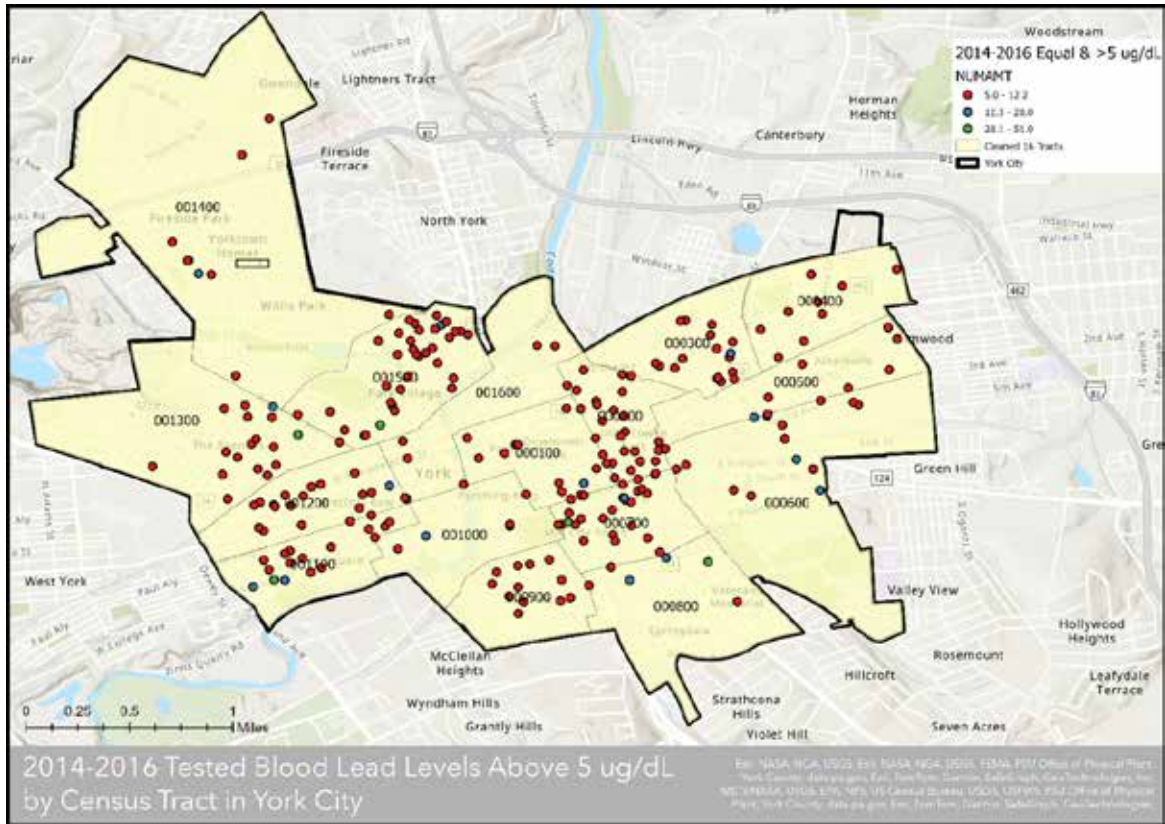
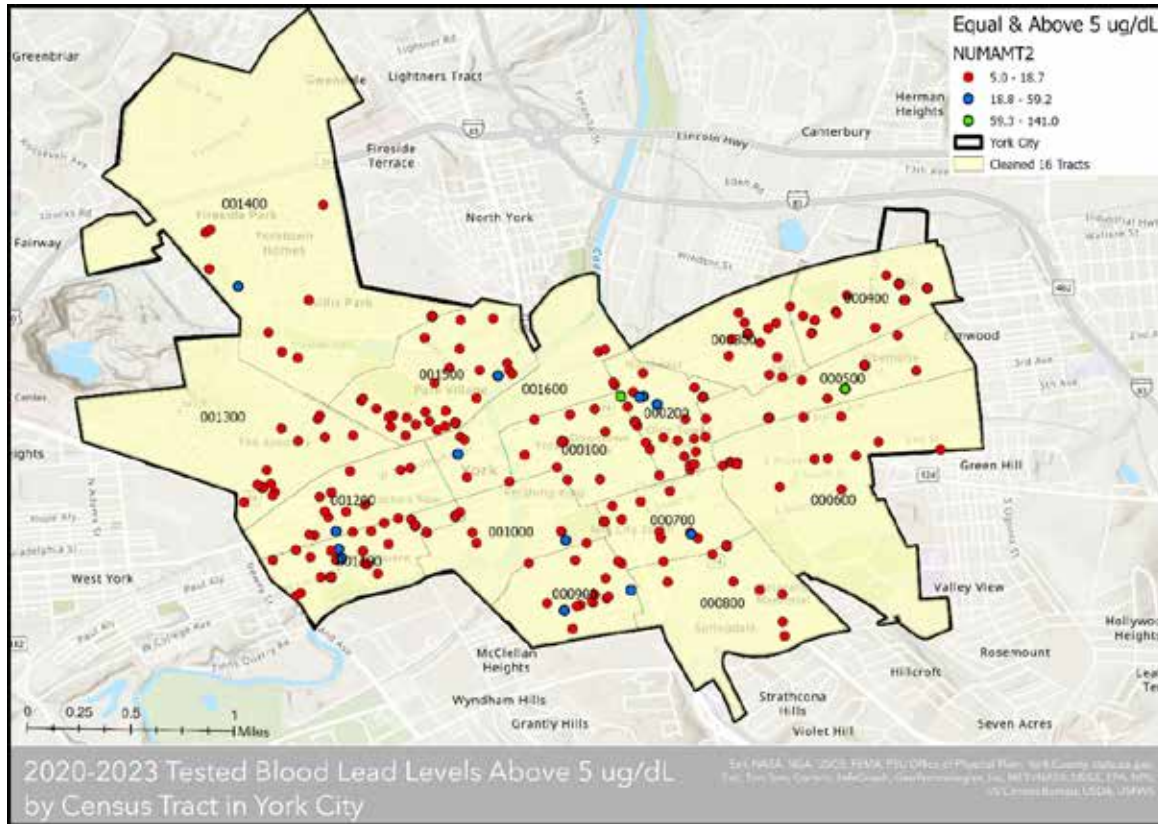


Figure 2. 2020-2023 Elevated Blood Lead Levels (EBLL) above five ug/dL by census tract



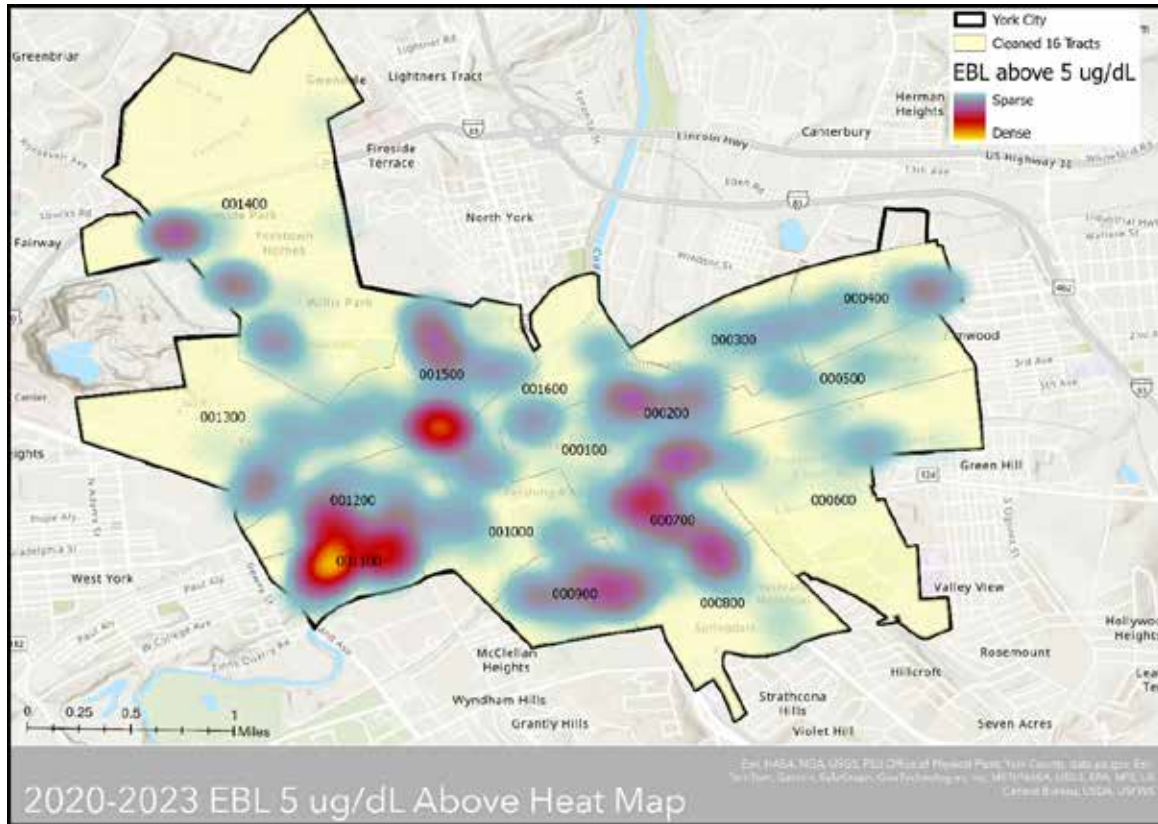
As seen in Figure 1, during 2014-2016, most of the elevated blood lead data (433 cases), represented in red dots on the first map, fell within the lead poison range of five-12.2 ug/dL. In the 2020-2023 period, despite the upper threshold for EBLL rising to 20 ug/dL, a similar pattern, shown in red dots, was observed in Figure 2. This suggests persistent lead exposure among children, which begs for public health interventions and prevention efforts to address the ongoing risk of lead poisoning.

We analyzed the census tract level to ensure privacy, which provides the best protection for sensitive information. Figure 3 highlights that the 001500 census tract in the darkest red color had the highest intensity of EBLL in York during that period. Figure 4 reveals several notable patterns:

1. **Bi-Tract Zone of the Highest Intensity:** This zone, represented by the brightest yellow within the largest red area, encompasses the 001100 and 001200 census tracts, both located near YCP.
2. **Secondary Highest Intensity:** A smaller, darker red cell area on the map is visible in the southeastern corner of the 001500 census tract, indicating a slightly lower but still significant concentration of EBLL.
3. **Tertiary Highest Intensity Zones:** On the city's eastern side, three distinct zones with moderate intensity are displayed. Notably, the largest of these is an “L”-shaped area encompassing the 000700 census tract.



Figure 4. 2020-2023 Elevated Blood Lead Levels (EBLL) five ug/dL above heat map



Note. EBL = Elevated Blood Lead Level, interchangeably with EBLL

These patterns illustrated on the two heat maps highlight that lead exposure risks have shifted and concentrated in specific areas over time, suggesting the need for localized interventions and public health outreach efforts, which are essential to mitigate lead poisoning risks to children’s health. The increase in the mean amounts of blood lead levels from 3.68 ug/dL in 2014-2026 to 4.03 ug/dL in 2020-2023 underscores the growing severity of lead poisoning risk. The neighborhoods identified are the hotspots because they are near and adjacent to the YCP campus. Such geographic proximity to the YCP campus means convenience for the college to work with various stakeholders to take action on these specific neighborhoods. Therefore, they should be designated as the priority areas where immediate actions, for example, more blood lead level testing, public education about lead poisoning, identification of lead sources, and targeted interventions, could be implemented through collaborative efforts between the college and community partners.

### Socio-Demographic Characteristics in the EBLL Hotspots

The relationship between socioeconomic characteristics and EBLL is an important study topic for understanding lead exposure risks. Factors such as age, sex, race/ethnicity, housing conditions, and income play a significant role in determining the likelihood and severity of lead exposure (Ettinger, 2022). Ettinger

(2022) states that race/ethnicity, low socioeconomic status, and housing age are not evenly distributed. Examining these socioeconomic characteristics is essential for identifying vulnerable population groups and tailoring effective public health interventions to mitigate the long-term impacts of lead poisoning. This section presents the characteristics and correlations with EBLL among children in York, shedding light on the broader context of environmental justice and public health. The GIS analysis conducted also highlights the complexity of these characteristics.

When analyzing the number of children tested for lead exposure by sex, male children were found to have higher rates of detectable lead levels in their bloodstream than those reported as female. Between 2014 and 2016, 1,200 children identified as male (53.03%) were tested compared to 1,062 children identified as female (46.93%). This pattern persisted during 2020-2023, with 1,576 children identified as male (69.64%) and 1,451 children recorded as female (47.94%). Over the nine-year period, the EBLL was consistently higher among children identified as male compared to those identified as female. Additionally, lead contamination levels increased across groups, with a 16.61% rise among children identified as male and a 1.01% growth among children identified as female. The gap in lead exposure rates between these groups widened over time, increasing from 6.1% in 2014-2016 to 21.7% in 2020-2023.

When comparing race and ethnicity, out of the categories of White, Black, Asian, Race of Other, and Race Unknown, the Black category had the highest recorded number of children with detected lead poisoning, with 512 cases (24.39%) identified in the 2014-2016 dataset and 888 persons (35.51%) between 2020-2023, reflecting an 11.12% rise over the nine years. Ranking all categories from the largest to smallest based on the number of EBLL cases yields the following order: Black, White, Race of Other, Race Unknown, and Asian.

Notably, the Race of Other Category also substantially increased, from 413 persons (19.68%) in 2014-2016 to 906 persons (36.21%) in 2020-2023, marking a 16.53% growth. This trend suggests that York experienced racial and ethnic diversity over time, which mirrors the national trend. Additionally, the number of EBLL cases among children categorized under Race Unknown showed an upward trend, underscoring potential gaps in the accuracy and completeness of data collection. Addressing EBLs requires improved data collection practices to ensure comprehensive and reliable demographic information. Such efforts are crucial for designing equitable and effective public health interventions to combat lead exposure in vulnerable local communities.

Age is another important socioeconomic factor related to lead poisoning among children. Our analysis found that children aged 0.9 to 1.4 were the most affected age group for detected EBL. However, this age group experienced a decline in prevalence over the nine-year period, dropping from 46.71% in 2014-2016 to 39.24% in 2020-2023. There was also a notable shift in the ranking of age groups over time. During 2020-2023, children aged between 0.9 and 1.4 accounted for the largest proportion of EBL tests in York, maintaining their position as the most impacted age group. Meanwhile, children aged 1.9-2.3 years old were the smallest age group in 2014-2016, which increased to the second-largest age group in 2020-2023. These trend characteristics highlight that targeted community outreach and public health interventions should focus on the ages 0.9 to 2.3 because they are the most vulnerable to the harmful effects of lead poisoning.

Regarding language, the number of English-speaking families tested for EBL rose significantly, increasing from 65 cases in 2014-2016 to 167 cases in 2020-2023. Spanish-speaking families experienced the most notable growth, rising from 16 to 80 cases during the same period. Conversely, the categories Unknown and Other Languages showed a decline. Families categorized under Other decreased from 377 children in 2014-2016 to 214 cases in 2020-2023; the Unknown category dropped from 300 children

in 2014-2016 to 149 in 2020-2023. These shifts highlight changing linguistic demographics among EBLL-tested families, emphasizing the importance of culturally and linguistically tailored public health initiatives to address lead exposure risks effectively.

## **Building Structure Characteristics and EBLL**

Building structures play a critical role in influencing the risk of EBLL, particularly in older housing and poorly maintained environments. According to local experts in York, lead exposure is most commonly linked to lead-based paint, which was widely used in construction until its ban in 1978 in the United States (C. Legg Wood, K. Houck, & M. Howie, personal communication, August 29, 2024; C. Legg Wood, K. Houck, & M. Yingling, personal communication, July 17, 2024). Home structures built before this date are especially prone to containing lead-based paint. As the paints age, they deteriorate into flakes and dust, creating a primary pathway for lead exposure. Activities such as renovation or maintenance can further worsen the issue by disturbing lead-containing materials, exacerbating the problem as they release lead particles into the air and onto surfaces where they can be easily ingested or inhaled. Our analysis found that 79.29% of the existing structures in York were built before 1978. Among these, 98.59% of these pre-1978 buildings are residential structures. This overwhelming share of pre-1978 residential structures suggests a significant likelihood of lead-based paint presence and associated environmental deterioration in these buildings. Such conditions need comprehensive measures, including lead paint remediation, public awareness campaigns, and policies to ensure safe living environments and renovation practices so health risks associated with lead exposure can be mitigated.

GIS mapping of York's 2024 structures data revealed that residential land uses dominate, comprising 82.14% of the total. The next most significant category is commercial land use, accounting for 7.72%. Tax-exempt land, classified as "Exempt," follows at 5.84%. Industrial land use represents a smaller portion, making up just 2.2%. The remaining land use categories, agricultural and utility, occupy the smallest shares of the city's land use distribution.

The heat map, shown in Figure 5, illustrates the intensity of structures built before 1978. Notably, the pattern of these older structures closely aligns with the spatial distribution pattern of EBLL  $\geq$  five ug/dL at the census tract scale. The most prominent hotspots, represented in the brightest blue, include census tract 001100 (closest to YCP), tract 000700 (shaped like an "L" in the East-central part of the city), tract 000900 (situated in the South-Eastern central city), and tract 000300 (located in the North-Eastern part of the city). The spatial overlap suggests that areas with higher densities of pre-1978 buildings may serve as proxies for identifying populations at greater risk of lead exposure. Developing comprehensive public health strategies tailored to the unique needs of each hotspot would mitigate the risks associated with aging housing infrastructure.

Figure 5. Structure buildings before 1978 heat map in York

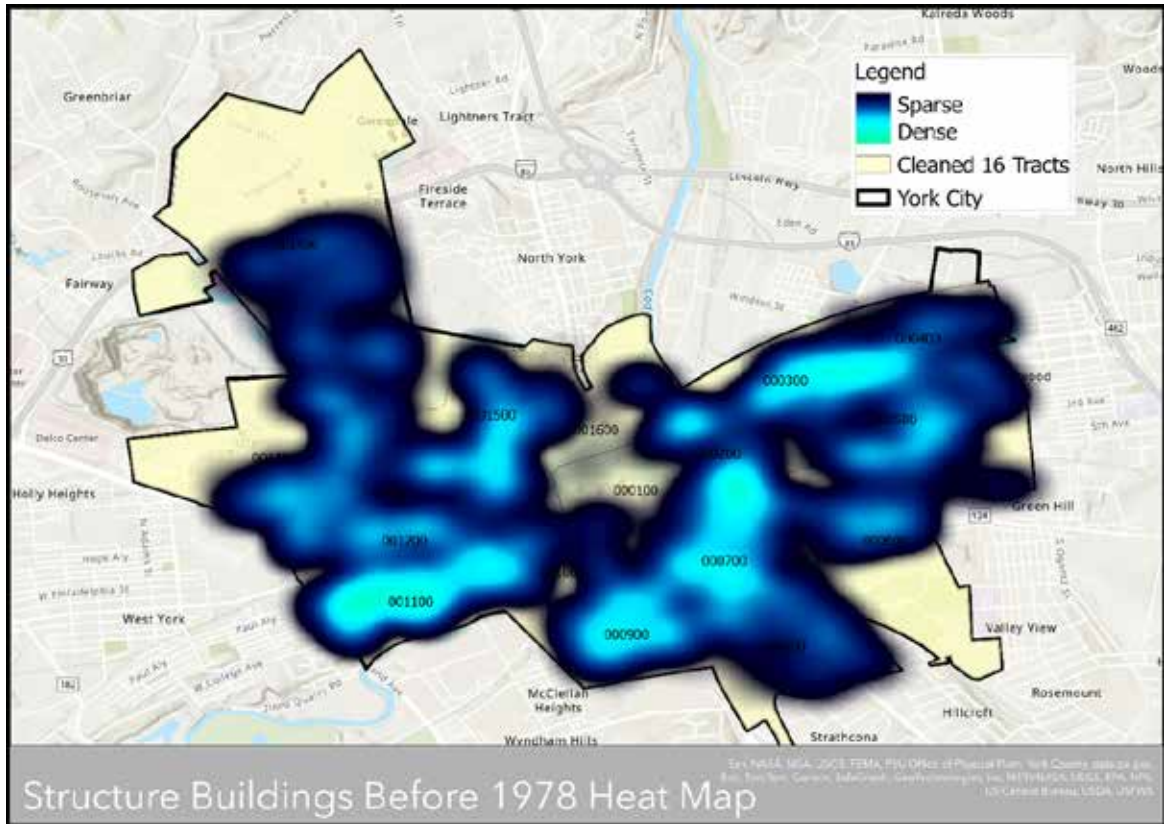
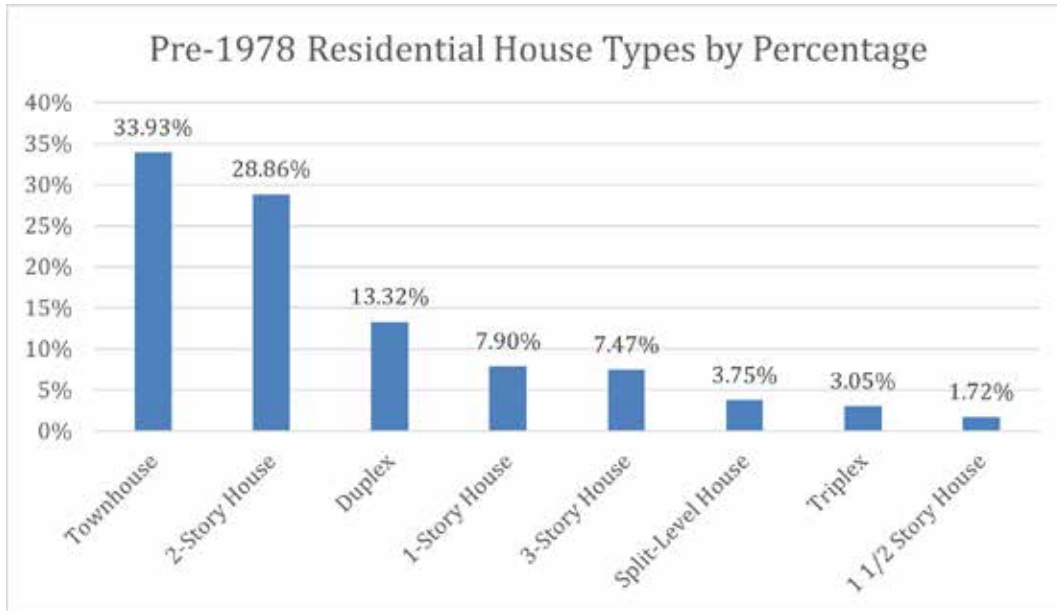


Figure 6 ranks the subtypes of pre-1978 residential structures. Townhouses account for the largest portion of residential housing, followed by two-story residential houses. Duplexes rank next, with one-story and three-story housing following in sequence. All remaining categories are also residential structures.

Figure 6. Percentage of pre-1978 residential housing by type in York



The prevalence of these pre-1978 housing types is significant because they are highly likely to contain lead-based paint, a primary source of lead exposure. As these structures age, lead-based paint deteriorates into dust and flakes. Once these settle on surfaces, they can be easily ingested, particularly by young children. This risk is compounded in poorly maintained homes, where peeling and chipping paint is more common.

Another critical factor is the condition of the building. Poorly maintained structures with peeling paint, cracked walls, and deteriorating woodwork are more likely to release lead into the indoor environment (EPA, 2024). Additionally, the presence of lead in plumbing systems, such as lead pipes, solder, and fixtures, could contaminate drinking water. Corrosive water supplies can accelerate the leaching of lead into drinking water, posing a severe health risk in households with young children (EPA, 2024; Pieper et al., 2017).

Given the prevalence of pre-1978 housing, EBLL is a major public health concern in York, especially among young children. Even low levels of lead in the blood ( $\leq$  five ug/dL) can affect a child's cognitive development, behavior, and overall health (EPA, 2024). The clustering of pre-1978 housing subtypes, such as townhouses and two-story homes, in areas with higher EBLL highlights the urgent need for intervention strategies such as lead testing, lead remediation, or lead abatement.

## Implications for Community Health

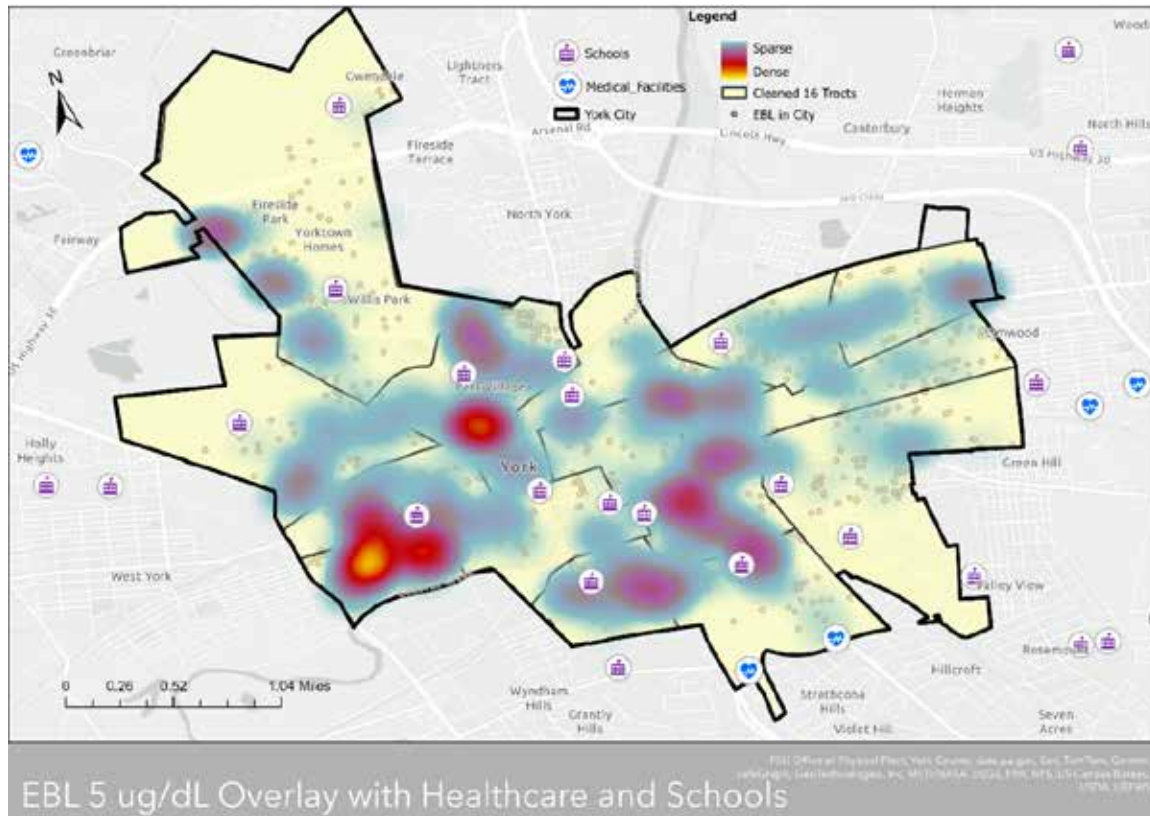
Between 2014 and 2023, blood lead levels showed a noticeable upward trend, stressing the critical public health implications of lead exposure. Research underscores the cumulative health risks associated with lead among children as they cause children's long-term development and cognitive function.

Lanphear et al. (2024) emphasize that adults retain 95% of lead in the skeleton, while children retain 70% in the skeleton, making children especially vulnerable to its harmful effects.

The CDC (2024) has declared that no safe level of lead exposure exists in children. Over time, the threshold for what is considered an EBLL had been significantly lowered. In 2021, the threshold moved from 5 ug/dL to 3.5 ug/dL (Office of Lead Hazard Control and Healthy Homes, Department of Housing and Urban Development (HUD), 2025), while in the past the threshold has been as high as 60 ug/dL in the 1960s (Gilbert & Weiss, 2006). Lead poisoning in children is linked to severe health outcomes, including preterm births, cognitive deficits, attention-deficit/hyperactivity disorder, high blood pressure, and reduced heart rate variability. For adults, lead exposure increases the risks of cardiovascular disease, kidney failure, and hypertension (Lead Free Promise Project, n.d.; *Low-Level Lead Poisoning Is Still Pervasive in the US and Globally*, 2024)

An analysis of related infrastructure—healthcare facilities and locations of the existing schools—revealed two interesting characteristics. Existing healthcare facilities are represented in the blue symbology of a heart with a zipper. Figure 7 shows a concerning mismatch between areas with EBLL and the availability of healthcare services provided by the existing healthcare facilities. Such disparity calls for urgent interventions and resource allocation to ensure that vulnerable populations, particularly children, receive timely and adequate care to mitigate the devastating effects of lead exposure. As shown in Figure 7 *Elevated Blood Lead Levels (EBLL) Five ug/dL Overlay with Healthcare and Schools*, Hotspot #1, Tract 0001000, few nearby healthcare facilities are equipped to provide lead screening, diagnosis, and treatment. This gap can result in delayed and inadequate care for children who are affected by lead exposure, exacerbating health outcomes.

Figure 7. Elevated Blood Lead Levels (EBLL) five ug/dL overlay with healthcare and schools



Note. EBL = Elevated Blood Lead Level

The proximity of schools in York was mapped because the most vulnerable population is children under six years old, and they typically attend daycare or early elementary schools. We found that the closest school to Hotspot #1, depicted in the brightest yellow and red on the map, is Lincoln Edison Charter School. This school serves students in grades K-5 and has an enrollment of approximately 700 students. Hotspot #2, located in the North-central part of the city, has a few schools nearby. Hotspot #3 is located on the Eastern-central in an “L” shape with a couple of schools within a distance of 170 meters. The average distance from each hotspot to the nearest elementary school is 321 meters. These elementary schools are likely high-risk areas. Allotting resources and interventions in these locations can be more effective in reducing lead exposure. Sharing EBLL information with parents, educators, and community members will empower communities to advocate for lead remediation programs, stricter regulations, and funding to protect children.

## Limitations

Systematic analyses strive to eliminate bias; however, it is important to acknowledge the limitations of this study. Instead of using annual blood lead test data, we utilized a three-year window for both the baseline and end periods, as was collected and tabulated by the City of York Bureau of Health. As a

result, some fluctuation trends within the middle period of the study timeframe could not be fully captured, potentially leading to inconsistencies in trend analysis.

Despite this limitation, it does not diminish the significance and value of our study. From both a student learning and community engagement perspective, this GIS research project provided an invaluable teaching-learning-acting workflow, fostering practical experiences applying GIS analysis and designing public health initiatives. Such an approach is particularly relevant in today's job market, where applied problem-solving and community-driven research are increasingly essential in college teaching.

## CONCLUSION

In conclusion, the analysis of EBLLs from 2014-2023 and spatial distribution patterns highlights the complexity of the lead contamination issue in York City. A key factor contributing to the high risks is the prevalence of pre-1978 housing, where deteriorating lead-based paint poses a significant risk. These aging structures continue to pose an important public health challenge, particularly among children, necessitating targeted, data-driven interventions to reduce the risks.

The GIS-based hot spot analysis reveals that EBLLs  $\geq 5$  under ug/dL are not evenly distributed in York City, but are concentrated in neighborhoods with older housing stock and higher proportions of Black, male children. The intersection of these two datasets is frequently overlapped with elementary schools, where young children are most demographically susceptible to the harmful effects of lead exposure as they spend significant portions of their time at school. This raises an urgent need for these schools to roll out lead abatement programs. Education in these schools must include educating the students and their families regularly about systematic lead monitoring and proper cleaning practices to minimize flakes and dust that might be present in their homes. In addition to these educational opportunities, stricter implementation of building codes and substantial remediation and abatement projects should be implemented in identified areas of need. Furthermore, the geographic mismatch between the census tracts with EBLLs and the distribution of healthcare facilities is a concern, underscoring the need for improved accessibility to medical interventions in the most affected hot spots neighborhoods.

While this study used 5 ug/dL for the EBLL threshold value, it is important to recognize that no lead level is safe. That means even lower levels of lead exposure can have serious health consequences. Research completed by Hanna-Attisha (2022) and Stingone et al. (2022) has shown that children exposed to lead at levels below 5 ug/dL can still have significant development impacts. As of 2021, the Centers for Disease Control decreased their threshold for concern from 5 ug/dL to 3.5 ug/dL in alignment with HUD's new lead policies (Office of Lead Hazard Control and Healthy Homes, Department of Housing and Urban Development (HUD), 2025). This emphasizes the importance of early detection, prevention strategies, and proactive policy interventions to reduce exposure risks.

To effectively reduce lead contamination in York City, it is crucial to identify and address the primary sources contributing to the lead poisoning issue. While local experts indicate that lead paint is the leading cause of EBLL in York City (C. Legg Wood, K. Houck, & M. Howie, personal communication, August 29, 2024; C. Legg Wood, K. Houck, & M. Yingling, personal communication, July 17, 2024), further research is necessary, particularly in mapping drinking water pipelines, to confirm lead contamination pathways and, therefore, guide intervention efforts. A data-driven approach will ensure that abatement strategies are targeted, evidence-based, and effective.

Integrating a project-based, service-learning project in an introductory-level GIS college course offers students a hands-on learning experience in spatial analysis while engaging them with a real-world public health challenge. Unlike traditional public health pedagogy, this approach allows students to apply cutting-edge GIS technology, fostering innovation, critical and analytical thinking, and direct engagement with community stakeholders (Alexander E S. et al., 2020). This learning model enhances computer technical skills and inspires students to think outside the box and appreciate the value of spatial, critical, and analytical thinking to address complex societal issues.

## Recommendations for Future Actions

Based on the findings, several key actions should be prioritized:

1. Expand Community Health Education Initiatives – Increase awareness about lead poisoning prevention by disseminating accessible information on exposure risks. For example, the StoryMap titled “Exploring Lead Contamination in York City, PA, 2014-2023” (<https://storymaps.arcgis.com/stories/f9ce3f6e19f948c0a3436835265f0549>) was designed and created by the student research assistant Helen Paglio can be shared with the residents who live in those hot spot areas and other community stakeholders. Schools located within the hot spots should be one of the primary sites for community education, which could involve YCP students in various majors, real estate agencies, community activists, and public health professionals.
2. Accelerate Infrastructure Improvements – Expedite the replacement of lead pipes and the renovation of older housing stock with deteriorating lead-based paint. Similar actions should be taken for the drinking water pipeline system.
3. Regular Lead Testing and Surveillance—Implement more regular testing systematically. Collect blood lead level test data in children under one-year-old with more granular documentation by month. Longitudinal data collection would also help study the longitudinal impact of the children who were exposed to lead contamination in their early life.
4. Develop Policy Solution for Equitable Remediation – Ensure that lead abatement resources are distributed equitably across all neighborhoods.
5. Promote Household-Based Lead Reduction Strategies – Residents living inside of hot spot areas should adopt key prevention measures, which include:
  - a. Regular maintenance includes cleaning surfaces, using HEPA filter vacuums, and washing children’s toys.
  - b. Regularly test drinking water for lead to ensure safety, using certified lead-reducing filters and flushing pipes for at least 30 seconds before use.
  - c. Reduce soil contamination by covering bare soil with mulch or grass in the yard.

Clearly, urgent actions must be taken to identify the sources of lead contamination in York City. While it can be assumed that the most likely causes of lead contamination throughout the city are lead paint, lead piping, or emission pollution, additional data collection should be implemented as research requires better and more data to confirm these assumptions and design the most effective mitigation strategies in York City.

Research completed by Billings and Schnepel (2017) underscores the far-reaching social and economic consequences of lead exposure, particularly in residential environments. They state that lead paint in residential housing significantly impairs children's cognitive and behavioral development with profound economic and social consequences. Their study estimates that every dollar invested in lead paint remediation yields \$2.60 worth of benefits, which include the return in public health benefits, reduced medical expenses, and enhanced quality of life. Addressing lead contamination in York City is not only a public health necessity but also an economically sound investment that requires a comprehensive approach that must begin with identifying and mitigating the primary sources of lead exposure. By prioritizing remediation efforts, cities like York City, in the Rust Belt in the United States, can protect their most vulnerable populations and build healthier, more resilient communities.

### **Future Research Directions**

Future studies related to lead contamination in York City could explore the co-morbidity between these EBLL cases and asthma at the census tract level because of seasonal air pollution associated with rapidly increased warehouse land use in South-Central Pennsylvania. Identifying common environmental risk factors for these conditions could be instrumental in shaping comprehensive public health strategies to improve overall community well-being.

### **Future Applications and Community Impact**

The Neighborhood Hub is a joint venture between the YCP CCE, The Urban Collaborative, and Four Squares Development, a local real estate development company and affiliated non-profit organization. The Neighborhood Hub program is designed outcome to support the work of the York County Planning Commission, the City of York Bureau of Health, the Land Bank Authority, the Stable Housing Collaborative, the newly formed Lead Task Force, and other local partners with a focus on increasing the availability of safe, affordable housing and reducing the number of children exposed to toxic lead in their homes. This program centers on creating a development model for York City housing growth that focuses on empowering local residents rather than encouraging gentrification. As a local community organization, the Neighborhood Hub would address York City's identified housing shortage by training local individuals who need career development, such as recent high school graduates and individuals exiting incarceration. With this, the Neighborhood Hub program will create a pool of local experts in various areas of housing-related careers. By collaborating with the Land Bank Authority to revitalize existing properties that are currently vacant and suitable for home renovation and those in need of repair and remediation and collaboration with the York County Planning Commission, the Neighborhood Hub can be the center impetus of increasing access to safe, healthy, and affordable housing for residents of York.

The findings from this project-based learning experience, led by Dr. Pomeroy and her students (e.g., Web GIS StoryMap), play a central role in shaping the Neighborhood Hub's data-based evidence-supported initiatives and programs. The GIS-created maps and other analytical outputs developed through this project are excellent for data visualization, communication, and education tools. Through either printed maps or interactive web GIS platforms, all stakeholders, including policymakers, healthcare workers, landlords, and the general public, will be educated, better understand the local lead poisoning challenge, and share the same community development objectives – to provide safe and affordable housing to people who live in York region. Through GIS-driven risk assessment, trained lead assessors, dust wipe

technicians, and lead abatement specialists, the Neighborhood Hub program will support the Bureau of Public Health in systematically detecting lead in paint samples rather than in children's blood tests. Additionally, The Neighborhood Hub can start training risk assessors, dust wipe technicians, and abatement specialists to increase the local capacity to test and remediate contaminated properties. Working with the York County Planning Commission, the Neighborhood Hub will support the development of a more streamlined approach to lead abatement within York City.

Currently, York City faces a significant shortage of certified lead abatement specialists. As of 2023, only one company in York City was licensed to do lead abatement, First Capital Insulation (U.S. Department of Labor and Industry, n.d.). A representative from that organization shared that they recently lost two of the three lead specialists, leaving them with one certified individual to do lead abatement. That person would be limited to the types of jobs they could handle solo (C. Legg Wood & First Capital Insulation Representative, personal communication, October 23, 2024). There are 15 companies based in Philadelphia and six in the city of Lancaster (U.S. Department of Labor and Industry, n.d.). Still, multiple individuals working in this area, including the representative from First Capital, described this as a “bottleneck” in getting homes safe for families (C. Legg Wood & First Capital Insulation Representative, personal communication, October 23, 2024).

The GIS-informed patterns and underlying processes highlight the urgent need for certified lead abatement specialists within the local community. The Neighborhood Hub program seeks to address this public health issue by filling the gap through working with Four Squares Development, civil engineering faculty, and other community partners to provide specialized training to local individuals and possibly also an involvement of the reentry coalition. Additionally, this initiative programming can engage recent high school graduates and other interested community members – with the necessary skills for lead remediation. Training efforts should be strategically directed toward those identified hotspot census tracts shown on the maps and other analytical outputs that Dr. Pomeroy and her students produced, alongside data from other York City entities. In addition, public education programs such as StoryMaps designed by Helen Paglio, the student research assistant at York College, should be used for community outreach into those high-risk census tract neighborhoods to educate local residents and families to ensure that their home is a lead hazard-free environment (Hauptman et al., 2017). Engaging community leaders and organizations from non-health related organizations brings valuable insight into the unique needs of the population (Alderwick et al. 2021), which will fuel those targeted systematic lead abatement efforts where YCP students, especially the students in the GIS courses, can apply their learned GIS skills in designing and generating scenario-based models.

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## KEY TERMS AND DEFINITIONS

**Project-Based Learning:** is an educational approach that combines learning objectives with community service projects, allowing students to engage in meaningful problem-solving by addressing real-world issues while gaining valuable insights and skills aligned with their coursework.

**Elevated Blood Lead Levels (EBLL):** refers to a blood lead concentration level that exceeds established public health thresholds, indicating potential lead exposure and associated health risks. For children under the age of six, EBLL is defined as a blood lead level at or above 3.5 micrograms per deciliter (ug/dL). For individuals over the age of six, a blood level of 5 ug/dL or higher is considered elevated. These thresholds are set by public health guidelines by the CDC, which serve as indicators for interventions and medical follow-up to prevent lead-related short-term and long-term health effects.

**Redlining:** is the historical practice of denying financial services, such as home loans, to people of color (POC) to segregate communities. From 1933-1939, the HOLC created “residential security maps” ranking neighborhoods by investment risk, with Black and immigrant communities marked in red as “hazardous.” During the 1934-1968 time periods, the FHA and private banks used redlining maps to deny home loans and insurance to residents in those redlined areas. In 1968, the Fair Housing Act, part of the Civil Rights Act of 1968, declared redlining illegal.

**Geographic Information Systems (GIS):** are computer systems for collecting, storing, analyzing, managing, and visualizing geographic data. They allow for the discovery of patterns and processes by creating professional maps that inform science and are designed artistically.

**Spatial Analysis:** examines geographic data to identify patterns, relationships, and trends based on location and attributes. Standard spatial analysis tools are buffer (proximity), overlay, density analysis, and hot spot analysis. These tools are used to solve spatial problems, make predictions, and lend data-driven evidence-based decision-making in fields such as epidemiology, public health, urban planning, and environmental management.

**Heat Map:** is a type of GIS mapping for data visualization. It shows the intensity or density of a specific attribute across a geographic area. It uses gradient colors, with brighter or darker colors indicating higher concentrations or values, making it easy to identify trends, patterns, and hotspots within the data.

**Hot Spots Analysis:** is a spatial analysis method in Geographic Information Systems (GIS). It refers to statistically significant spatial clusters or high or low values within a dataset, indicating areas with concentrated occurrences of a particular real-world phenomenon in a manner that is unlikely to be due to random chance.

**Spatial Mismatch:** refers to a gap between two geographic features or phenomena. GIS analysis organizes these geographic features or phenomena into geodatabases or layers. For example, healthcare facilities and services provided are not appropriately aligned with the needs of an area's population, highlighting gaps in planning, accessibility, or resource allocation.

**Design Thinking:** in project-based learning (PBL) with GIS is an iterative, student-centered teaching-learning approach that integrates creative problem-solving in real-world projects. This enables learners to connect directly with the local community from the beginning to the end, including defining community needs and designing innovative solutions based on spatial critical thinking, geospatial literacy, and data-driven decision-making skills.

**Active Learning and Problem-Solving:** is an instructional approach that engages students in the learning process through hands-on activities, critical thinking, and collaboration rather than passively receiving information to develop problem-solving skills.

**A high-impact Practice and innovation (HIPI) Course:** refers to creating a dynamic, student-centered learning environment that enhances student engagement, learning outcomes, knowledge retention, collaboration, and application solving real-world problem-solving.

## APPENDIX I

### Student Testimonial

“For the final project of my Introduction to ArcGIS course, I collaborated and worked closely with my professor, Dr. Pomeroy, to map lead contamination in York City from 2020 to 2023. Through the creation and development of this project, I was able to deepen my understanding of ArcGIS software, as well as improve and gain skills needed to operate the program. The main challenges I faced when completing this project were knowing the next steps that needed to be taken and visualizing the final product. The datasets provided by the York County Bureau of Public Health contained so much information that it was difficult to analyze and decide what should be utilized not only in the mapping but also in the charts created for my final paper. Dr. Pomeroy was able to provide some guidance in the analysis of this data, advising me to focus on factors such as age, sex, and amount of lead recorded. We then decided what charts were best and how to use statistical tools to make the data more digestible for a wider audience. Because the overall course focused primarily on the tools of ArcGIS, this project and assistance from Dr. Pomeroy was able to expand my knowledge on the analysis of datasets. As for the hurdle of being able to visualize and work toward my final product, Dr. Pomeroy was once again able to provide me with the resources I needed to be successful in this project. Not only did she point out examples of what my final maps could be modeled after, but she also helped me to plan out the most important tools and steps I needed to achieve that product. However, she did not completely walk me through every step and tool. I was given the space and opportunity to explore different methods and reach my goal by myself. I was merely given the stepping stones that led to a major growth in my abilities when it comes to working with this software. After one meeting of brainstorming and questions answered by Dr. Pomeroy, I was able to confidently proceed with and complete this project independently. In the future, working on more ArcGIS projects and conducting further research, I will be able to reflect on this experience and how much it improved my learning and knowledge.” (Lydia Sanderson, Environmental and Sustainability Studies, Class 2027).

## APPENDIX II

### Student Testimonial on Lead Research

“Effective communication of scientific research is integral to conveying a better understanding to a broad audience. That is why I enjoy working with the GIS platform as a method of communication. The visual impact of mapping through GIS allows me to convey information in a dynamic way that helps people understand complex data. In conducting research this last semester on lead levels in the pediatric population of York City, PA, I was able to translate the data collected into heat maps that visually represented the “hot spots” of elevated lead levels in various areas of York City. Furthermore, we broke that data into gender and time periods so that we could visually analyze differences in the population demographics over time.

The permanent physiological damage to children with elevated lead levels cannot be overstated. The implications to our communities is far reaching and, according to research, impacts our population's IQ, our overall health, and even increases rates of crime. Further, it impedes an already struggling population of marginalized and low income families. I've seen this directly in people I care about. One young adult who is close to my family is a single mom struggling to raise her son in York City. Her now preschool age son is non verbal, autistic, and has many sensory processing disorders. He has been kicked out of multiple daycare settings because facilities were unable to meet his needs safely. This has led to significant stress and loss of income for his mom who cannot work without safe childcare. His mom has also had to dedicate time, money, and energy into figuring out why her son struggled so much. Testing through the pediatrician revealed that her son had elevated blood levels of lead. Since the testing, his mom has been able to build systems of support for his special needs. However, the impact of these elevated blood levels will be a lifetime of struggle and lost potential for both mother and son.

We need more testing. We need lead remediation to reduce the numbers of children poisoned by environmental lead exposure. To do that we need to communicate the severity of the problem and who is directly impacted by it. I hope that my work on GIS mapping last semester helps people understand the scope and magnitude of the lead problem” (Helen Paglio '25, Environmental & Sustainability Studies).

### Questions and Answers

What is the overall problem presented in this case?

How is lead poison hazard in blood spatially distributed in York City, south-central Pennsylvania?

**Answer:** Lead exposure in children's blood was unevenly distributed in York City, Pennsylvania.

Of the 16 census-designated census tracts, seven tracts are:

Within the two identified hot spots, which corresponded to the distribution of the pre-1978 existing residential building structures.

4. What are the factors affecting the problem(s) related to this case?

**Answer:** Age of residential building structures, demographics, socioeconomic status.

Discuss managerial, organizational, and technological issues and resources related to this case.

- Managerial and Organizational Issues: Despite multiple planning meetings between the center for community engagement (CCE) Director, Carly Legg Wood, and Dr. Jennifer Pomeroy, there remains potential for greater student involvement in the research project. There might be gaps in motivating more students to participate. Further raising awareness of the opportunity to increase participation.

What role do different players (decision-makers) play in the overall planning, implementation, and management of the information technology applications?

- Strategic planning meetings between the CCE Director, Carly Legg Wood, and the faculty, Dr. Jennifer Pomeroy (geographic information systems [GIS] specialist):
- Dr. Pomeroy mainly implemented day-to-day research involving a couple of undergraduate students.

What are the possible alternatives and pros and cons of each alternative facing the organization in dealing with the problem(s) related to the case?

- Increase the visibility and raise awareness of such research opportunities available to students, leading to greater participation. For example, the student researcher should be presented with a certificate upon project completion.
- Adjusting timelines might allow for more and easier participation without conflicting with students' other academic responsibilities.
- Reducing the faculty's teaching load would allow for enhanced mentorship.

What are some of the emerging technologies that should be considered in solving the problem(s) related to the case?

- Nothing else. GIS is a cutting-edge technology. Its output of StoryMaps is an excellent community education tool for targeted community outreach and education on the lead hazard issue.

What is the final solution that can be recommended to the management of the organization described in the case? Provide your arguments in support of the recommended solution.

- Wider messaging of the benefits of student research experience to increase awareness and thus more participation.
- Enhance support to faculty and mentorship.
- Improved collaboration and communication.

## **Epilogue and Lessons Learned**

The Geographic Information Systems (GIS)-based lead hazard mapping project for the local community was a successful experience for all, from once a conceptual idea to a powerful tool for improving public health and safety. GIS technology allowed data-based collaboration because the project has not only identified the hot spot areas with lead risks but also empowered local residents, health officials, and policymakers to take proactive measures.

After months of data gathering, cleaning, preparing, and rigorous GIS analysis, the final maps offer detailed visualization of lead hazards, including lead-based paint in older homes. This map serves as a vital resource for prioritizing remediation efforts, guiding funding allocations, and informing educational campaigns aimed at reducing lead exposure risks. In doing so, the project has significantly contributed to safeguarding the health of vulnerable populations, particularly children, who are most susceptible to lead poisoning.

The collaboration between the YCP's CCE, the GIS professionals, and community leaders has set a precedent for college-community partnerships in future public health initiatives. The project's success is also a reminder of the importance of data-driven decision-making as well as the need for ongoing engagement with the community to ensure sustainable outcomes.

As we look ahead, the GIS lead hazard map will continue to evolve; we hope to incorporate real-time data, resident feedback, and new environmental findings. With the power of GIS technology and collaboration with CCE, we strive to address pressing public health issues and create safer, healthier communities.

