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Exploring Qualitative Relationships Between Lead (Pb) Concentrations in Road Sediment and Aspects of Crime Statistics in Larger Urban Centers: Establishing Frameworks for Detailed Statistical Analysis.

By

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Abstract

Lead (Pb) poses significant health risks to humans by affecting the brain and nervous systems, causing learning and behavioral problems. Children absorb Pb more easily than adults, leading to effects on children's growth and development. Therefore, Pb exposure may contribute to societal issues such as increased crime rates in regions with high levels of Pb exposure. Pb can be found in different mediums such as paint, soil, road sediment, water, and air, which pose risks even when small amounts are found. This research explores possible associations between the reported crime rate in the cities below and levels of Pb found in the environment in road sediment and additional media when available. Crime rates of sites where road sediment was analyzed for the occurrence of Pb were assessed qualitatively to explore potential quantitative paths forward for evaluating Pb concentrations and criminal statistics.

Gary, IN, is known for its steel industry, which is believed to be a major contributor to the pollution that is found there today, disproportionately affecting African Americans who live near the industry. Gary, IN, has reported crime rates, at times, over four times the national average this year. Philadelphia, PA, is also known for its high crime rates and a history of shipping and industry contributing to its pollution. One of the major industries was Pb smelting, and at one time, it had 36 smelters, making Pb pollution one of the major concerns in the area. Previous studies found high concentrations of Pb in bulk and finer soil samples in Fishtown, PA, indicating pollution largely from paint and gasoline. Las Vegas, NV, crime rates are up to twice the rate of the national average. Las Vegas, NV road sediment was collected, indicating bulk concentrations of Pb were elevated environmentally but lower than those in other studies. Pb concentrations in road sediment show a broad, qualitative correlation with aspects of crime in locations studied; however, more extensive sample populations of road sediment and more crime

statistics with higher spatial resolution are required for more quantitative work. This initial assessment sets the stage for an extensive study of Pb concentrations in road sediment in urban areas and crime rates.

Introduction

Lead is classified as a chemical element with the symbol Pb and an atomic number of 82 (U.S. National Library of Medicine, 2025). At room temperature, it is a solid yet soft metal. Lead is dense and ductile. It is also very stable, resistant to corrosion, and a poor conductor of electricity while being an effective shield against radiation (Centers for Disease Control and Prevention [CDC], 2023). Due to these properties, it has been used by humans for many years. This practice dates back to the Ancient Romans, who used lead for plumbing and other uses (CDC, 2023). In more modern times, Pb was added to both paint and gasoline in order to improve performance (CDC, 2023). However, lead was banned in the use of gasoline for on-road vehicles on January 1, 1996, as part of the Clean Air Act (Environmental Protection Agency [EPA], 2016). Issues still arise from the remaining lead particles from past emissions. Particles have settled and have remained present from previous years, often accumulating in the nearby soil. Additionally, there was a federal ban on the consumption of lead-based paint in 1978, while other states had banned it even earlier (EPA, 2024a). Yet, lead-based paint is still commonly found in older homes and buildings, typically under layers of newer paint. When the newer paint starts to deteriorate, it quickly becomes a hazard as it may chip and then turn into dust, making it the most common way people are exposed in the United States (U.S. Department of Health and Human Services [USDHHS], 2025). Despite the various uses of lead, its toxicity is becoming more readily apparent and increasing in awareness, which has led to it being phased out in many products and raising concerns about its impact on human health and the environment.

There are many known health risks associated with lead exposure. They range from cognitive, learning, and behavioral issues to death. Children are particularly susceptible as lead interferes with brain development, particularly in regions responsible for impulse control and

social behavior. Studies have shown that children exposed to lead are more likely to develop behavioral problems later in life as a result of the negative effects Pb has on the brain. These children are more prone to engaging in delinquent or violent activities. Adults can be impacted as well, as lead targets important regions in the brain that can influence decision-making and emotional regulation. By impairing critical brain functions related to judgment, emotional control, and learning, lead exposure may play an indirect but prominent role in shaping patterns of crime in affected areas. This suggests that addressing lead contamination is not only a public health issue but also could be used as a potential means of reducing crime.

By studying lead contamination in urban environments, significant health risks can be addressed, shedding light on the possibility of Pb exposure leading to criminal activities, particularly in densely populated areas with industrial histories. Urban environments, with high concentrations of humans, infrastructure, and pollution, are often major areas for lead exposure. As lead does not break down over time, it can remain in the environment, continuing to be a problem from older material while hundreds of years of human activities continue to contribute to the increased levels of lead (EPA, 2021). It can eventually be redistributed and find its way into water supplies. In urban areas, lead exposure is often connected to socioeconomic disparities, often disproportionately affecting low-income and minority communities. Studying lead concentrations and their connection to broader societal issues is essential to guide public health policies, implement new and effective programs, and create a healthier, safer environment.

The purpose of this study is to explore the potential connection between lead contamination and crime rates in specific cities with a history of industrial pollution. By examining lead levels in road sediment and other environmental media, the study aims to identify patterns that may suggest a correlation between higher lead exposure and increased

crime rates. Using case studies from Gary, Indiana; Philadelphia, Pennsylvania; and Las Vegas, Nevada, this research attempts to address how lead contamination may contribute to societal issues such as violent crime and behavioral problems. This serves as a foundation for future, more comprehensive, and expansive research to be conducted to better understand the correlation and potentially establish causation between lead exposure and crime.

Gary, Indiana, is in Lake County on the southern shore of Lake Michigan, located 25 miles from downtown Chicago. According to the 2023 census, the population was around 67,000 (U.S. Census Bureau, 2024). It is known for its large steel mills, such as U.S. Steel Gary Works. Road sediment collections were made, leading to Scanning Electron Microscopy (SEM) images, indicating lead particles found in the sediment. Samples of road dust and soil were taken in Fishtown, Philadelphia. This town is located northeast of Center City and west of the Delaware River in Pennsylvania. In general, it is known for its shipping and industry, with previous sources of pollution stemming from chemical processing, smelting, and more (O'Shea et al., 2021). Analyzed were SEM images and Energy Dispersive X-ray analysis (EDX) spectra of Pb particles found in the road dust and soil samples (O'Shea et al., 2021). Lastly, road sediment was collected in different locations in Las Vegas, resulting in SEM Backscattered Electron Detector (BSD) images and respective Energy-dispersive X-ray Spectroscopy (EDS) spectra of road sediment particles containing heavy metals such as Pb, Mn, Fe, and more (Gokey et al. in review, 2024). Each of these cities was compared using violent crimes such as aggravated assault to the average of the United States using the FBI's Crime Data Explorer.

Background on Lead and Its Health Risks

Lead is a potent neurotoxin that poses serious health risks to both children and adults. The toxicological effects of lead are primarily due to its ability to interfere with different and

various biological processes. Pb distributes from the blood into the tissues within 4 to 6 weeks (Chaudhari et al., 2019). Its most damaging effects are on the hemopoietic systems, while some of the visibly affected systems are the nervous, reproductive, and excretory systems (Chaudhari et al., 2019). Lead exposure has the potential to impact the plasticity of dendritic spines within the CA1 regions of hippocampal neurons and disrupt the structure of neuronal mitochondria (Su et al., 2025). The CA1 is an area of the hippocampus that is critical for memories like autobiographical and the consolidation process, while proper mitochondrial function is essential throughout a neuron's life, including birth, development, synaptic transmission, and repair (Rangaraju et al., 2019). This means that if disrupted, neurons can be negatively affected, impacting brain function and cognitive abilities. Children have faster breathing, gastrointestinal absorption rates, a large surface area per unit of body weight, and underdeveloped defense mechanisms, making them more susceptible to lead exposure (Kuang et al., 2020). Due to this, exposure can have a great impact on their growth and development, alongside their behavioral and intellectual developments. Lead can lead to a variety of neurologic disorders, particularly in children, and high levels of lead in an individual's system can harm cognitive development (Kuang et al., 2020). This can lead to impacts beyond cognitive abilities and have social consequences, such as impacting school performance or social interactions. Lead exceeding certain levels can cause death, coma, and seizures (Wang et al., 2009). A study conducted by Wang et al. found that lead poisoning in children can lead to shortened attention spans and behavioral problems alongside cognitive retardations (2009). It was additionally reported that academic performance, IQ, and neurobehavioral developments of children decrease with greater levels of lead exposure (Wang et al., 2009). Children with higher bone lead often display more aggressive and delinquent behavior (Wang et al., 2009). Lead exposure in adults can lead to

other various effects, such as those on their reproductive systems, brain damage, kidney damage, high blood pressure, and more.

Lead is stored in the body, particularly in bones and teeth. It is very persistent (EPA, 2024a). It can build up over time, especially when a person is exposed to lead over an extended period. Unlike other toxic substances that can be quickly processed and eliminated by the body, lead is not easily excreted. Instead, it is absorbed and stored. This could be explained as Pb shares some chemical similarities with calcium ions (Ca2+) (Ferreira de Mattos et al., 2017). The body's inability to remove it effectively means that lead exposure can have long-lasting effects. Over time, this accumulation can lead to toxicity, even from low-level exposure.

Sources of Lead Contamination

Historically, lead was widely used in a variety of products due to its physical properties. Some of the most significant historical sources of lead contamination include lead-based paints, leaded gasoline, and industrial processes, all of which contributed to the widespread environmental presence of lead. Before the dangers of lead were fully recognized, lead-based paints were commonly used in homes, schools, and other buildings. These paints remained relatively popular until they became banned in the late 1970s. This paint deteriorates over time, which leads to lead dust and chips that are harmful when they are inhaled or ingested. Children are particularly vulnerable as they often come in contact with this substance by putting their hands in their mouths and touching many surfaces. As for gasoline, lead was added in order to improve performance and reduce engine knocking. Engine knocking occurs when fuel does not burn evenly in your engine. Leaded gasoline released lead particles into the air and surrounding soils. Although it has been phased out, the residual contamination still remains in many areas, contributing to persistent lead exposure. Additionally, many industries, particularly those

involved in metalworking, smelting, and manufacturing, use lead, releasing it into the environment. Even after the closure or regulation of such industries, the damage caused still remains in the form of contaminated soil, water, and air.

Currently, lead is commonly found in soil, especially in urban areas where past industrial activities have occurred or where lead-based paints and gasoline were used. Soil near older buildings, roads, or former industrial sites can contain high levels of lead. Lead contamination in drinking water also remains a concern in many cities with older infrastructure containing lead pipes. Lead can and continues to contaminate the air, particularly in areas near industries that still use it. Road sediment near roadways is also a common source of lead, as past emissions from leaded gasoline or wear and tear on vehicles and tires can build up in road sediment.

Impact of Urban Environments on Exposure Levels

Urban environments in the United States are vulnerable to high lead concentrations due to various reasons, such as industrial activity, high population, and aging buildings. The older the city, the higher the chance of it being contaminated (Levin et al., 2021). Many cities with a long history of manufacturing have elevated levels of lead in the environment. Older cities often have outdated plumbing systems, lead-painted buildings, and neglected roads that can contribute to lead exposure. In particular, urban areas with poor infrastructure may not have the necessary resources to address lead contamination, leaving their residents exposed. The dense population in urban areas also means that even small amounts of lead can have significant public health consequences. Furthermore, urban environments may have social inequalities that worsen the effects of lead exposure. Low-income communities that may be located near industrial sites or have older housing with lead paint are disproportionately affected by lead contamination. These

communities have limited access to the resources needed to mitigate the effects of exposure, further worsening the issue.

Environmental Lead Exposure in Urban Areas

Road sediment refers to the collection of dust, dirt, debris, and other particles that accumulate on road surfaces. It is found in every urban, suburban, and rural community making it accessible for research; yet it is understudied and valuable for pollution research (Dietrich et al., 2022). It is useful in relating to concerns of pollutants, especially in areas that are socioeconomically disadvantaged (Dietrich et al., 2022). In regions that have a history of industrial activity and high traffic, road sediment may contain high levels of lead. When moved, for example, by traffic or weather conditions, these particles can become airborne or enter the water system, continuing to pose a threat to public health. There are several ways that lead contamination can occur in road sediment, such as through vehicle emissions as the primary way, industrial pollutants, deposition from previous years, or even yellow traffic paint. One of the major concerns surrounding road sediment is the lack of regular testing and cleaning of roadways in many urban areas. It can accumulate for years at a time, demonstrating the need for remedies such as street sweeping (Dietrich et al., 2022). This can be a result of the focus on other sources of lead exposure, as road sediment is often underrepresented (Dietrich et al., 2022).

Lead Exposure and Criminal Behavior

It is commonly stated that there are no safe levels of lead exposure; even low-level exposure has proven to be detrimental (Dietrich et al., 2019). Therefore, lead exposure has been recognized as a significant environmental risk factor for neurodevelopmental and behavioral problems, especially in children. Many studies have been done in order to address this significant

issue. One case study of a young female found that Pb poisoning resulted in dramatic regressions in social behavioral functioning after high-level intoxication (Dietrich et al., 2001). A survey conducted in Philadelphia youths in the Collaborative Perinatal Project stated the strongest predictor of criminality in males was a history involving Pb poisoning (Dietrich et al., 2001). In a controlled study of 216 delinquent youths, those with significantly higher bone Pb concentrations were found to be the delinquent youths in comparison to sociodemographically matched controls in Pittsburgh (Dietrich et al., 2001). As lead involves the alterations of the central nervous system, several of the processes involved can be a part of the epigenesis of antisocial behavior (Dietrich et al., 2001). Early exposure to lead can result in interference with synaptogenesis, disrupt apoptosis, and lower levels of serotonin (Dietrich et al., 2001). Synaptogenesis is the process by which neural connections are made, while apoptosis is the process by which unwanted cells are eliminated. Serotonin is often referred to as the "feel-good" neurotransmitter as it contributes to happiness. It is also involved in other various bodily functions such as sleep, appetite, cognitive processing, and behavior.

Lead poisoning is also known to affect and lower IQ. There are many forms of evidence suggesting that violent behaviors are more frequent in individuals with lower IQs (Carpenter & Nevin, 2010). It has been found that "lead-exposed children suffer irreversible brain alterations that make them more likely to commit violent crimes as young adults" (Carpenter & Nevin, 2010, p.260). Aggressive behavior and impulsivity are major factors as they lie within parts of the brain that become altered with lead exposure. These long-term implications of lead exposure are significant as the damage can be permanent, and children exposed at a young age may continue to experience cognitive and behavioral difficulties throughout their whole lives. Impairments in impulse control, aggressive behavior, and decision-making, in particular, can

lead to long-term social consequences, including difficulties with employment, relationships, and involvement in criminal activity. Children with lead-related cognitive impairments may face challenges in school, leading to lower employment opportunities and higher rates of poverty. In return, this contributes to social problems such as crime, substance abuse, and mental health disorders in adulthood.

Methodology

This study uses a qualitative approach to examine the correlation between lead levels in road sediment and crime rates in three cities: Gary, IN; Fishtown, PA; and Las Vegas, NV. The methodology is designed to ensure a comprehensive analysis of environmental contamination and its potential social impacts, establishing a potential correlation of the relationship between lead exposure and crime. This study utilized a convenience sampling approach, as the data and literature for the three cities were pre-existing and provided by Professor Mark Krekeler, Miami University. The selection of these locations was based on the availability of previously collected environmental and crime data rather than a randomized sampling strategy. While this approach may limit generalizability, it allowed for the use of well-documented datasets.

Environmental data was collected through road sediment sampling from various locations within the three cities. Sampling sites were selected based on historical industrial activity, traffic density, and proximity to residential areas. Road sediment samples were gathered using standardized protocols to minimize contamination and ensure consistency. The collected sediment samples were analyzed using Scanning Electron Microscopy (SEM) to determine lead concentration. This technique allowed for high-resolution imaging, providing detailed insights into the characteristics of lead contamination.

Archival crime data was obtained from publicly available law enforcement databases, detailing crime rates and types within each city. The FBI's Crime Data Explorer (CDE) was the primary source of crime data. The crime data corresponded to the sediment sampling locations, ensuring a correlation between environmental contamination and crime.

Gary, Indiana

Gary, Indiana, is one of the most populated areas in North America (Dietrich et al., 2019). In previous years, it was known for the U.S. Steel Gary Works plant, which was a contributing factor to air pollution. While there has been a decline in industry, pollution still occurs. In a study by Dietrich et al., the authors decided it was a beneficial study site for road sediment as it is representative of a mid-size city and the previous heavily industrialized steel production (2019). It is also representative of cities moving away from industrialization. The study area surrounds a north-south transect down Broadway south of U.S. Steel (Dietrich et al., 2019). Dietrich et al. took 32 samples for bulk chemical analysis and particulate characterization, with 19 samples along the north-south transect down Broadway and 13 along an east-west transect along East 11th Avenue on June 26, 2016 (2019). EDS data indicates high concentrations of Pb showing mixed sourcing in addition to atmospheric deposition from the U.S. Steel facility, as air monitoring in Gary, IN, shows Pb deposition via atmospheric particulates (Dietrich et al., 2019).

Gary has seen significant economic declines and social challenges, including high crime rates. Aggravated assault is one of the more common violent crimes reported in Gary, with the city often experiencing crime rates several times higher than the national average. However, even

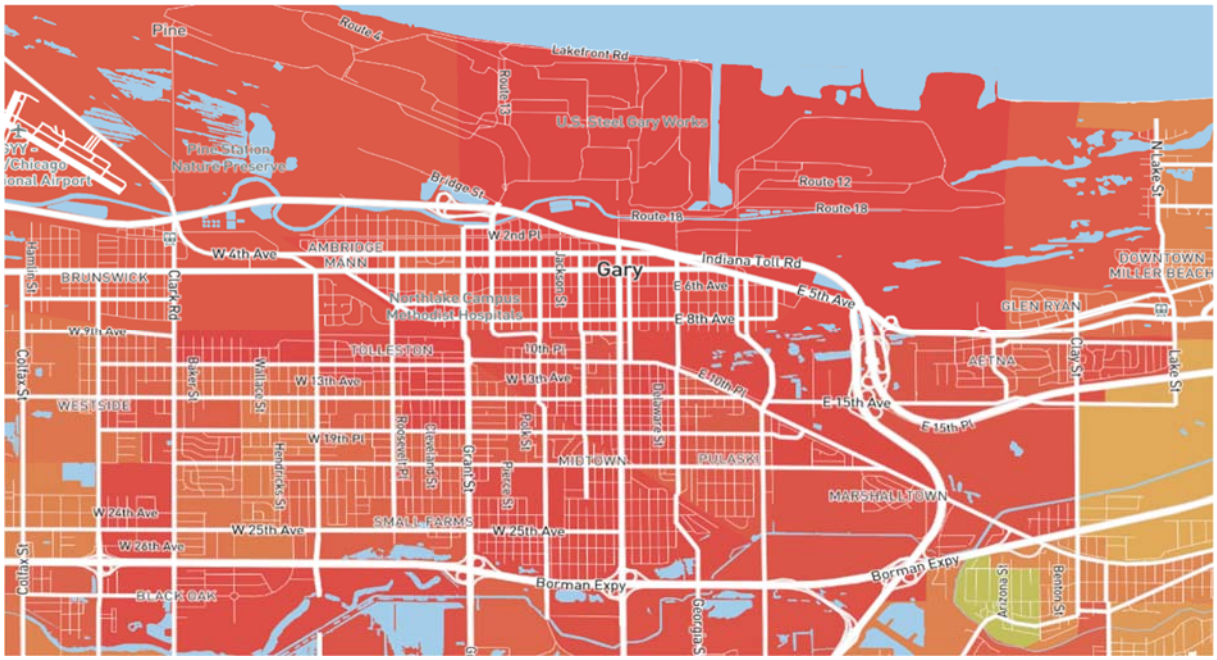

Fig. 1. Crime map of Gary, IN from crimegrade.org indicating the high volume of crime in the area and nearby locations. The darker the red, the higher the associated crime rate of the area.

more concerning is the homicide rate, which has remained almost consistently higher than the national average since 2000. Robbery is similar to homicide as it remains much higher than the national average with rape reflecting aggravated assault, reaching heights above the national average but not consistently.

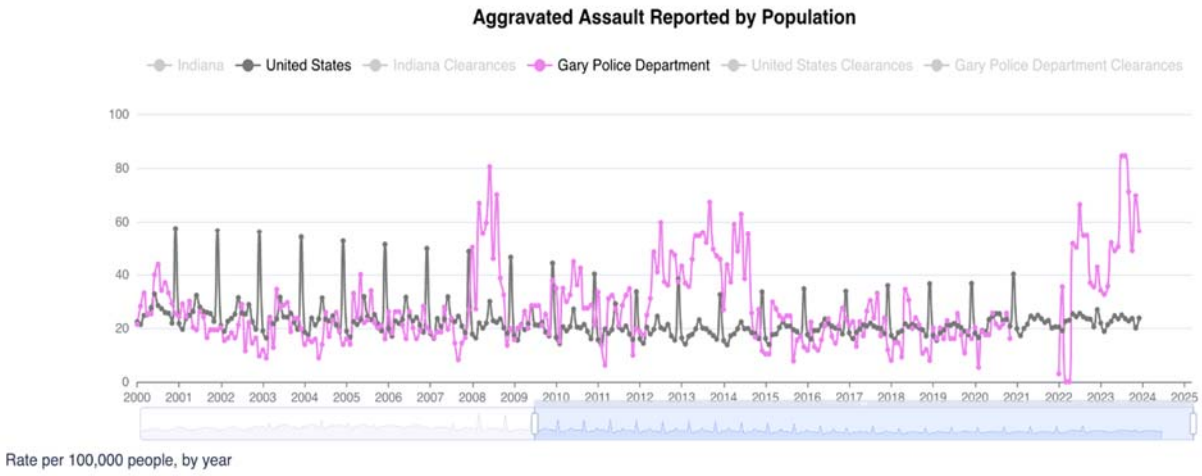

Fig. 2. Crime reports reported by the Gary Police Department per 100,000 per year since the year 2000. This information is found on the FBI's Crime Data Explorer showing the comparison between Gary and the United States.

Fishtown, Philadelphia

Philadelphia has a history of shipping and industry with previous sources of pollution, including chemical processing, tanning, metalworking, textile production, and melting (O'Shea et al., 2021). Smelting in particular was a major industry, primarily from the late nineteenth century through the mid-twentieth century, at one point having 36 active Pb smelters, making Pb pollution a concern (O'Shea et al., 2021). Areas included in the study had previous Pb smelters. A previous study found Pb levels higher in soils near former Pb smelters than residential sites, however, it is important to note that Pb contamination is widespread and not limited to areas near smelters (O'Shea et al., 2021). Other sources of lead originate from Pb paint and leaded gasoline.

O'Shea et al. collected road dust and soil samples in October 2017 at twenty sites within the Fishtown neighborhood (2019). Some sites were chosen because of their distance to former smelting locations, and the rest were semi-randomly selected in a grid pattern, as long as they were adjacent to publicly accessible soil patches (O'Shea et al., 2021). Residential streets were the main focus. As for soil sampling, they were collected within 2 meters of the sites of road dust collection, and public spaces were used due to the proximity to the street and ease of accessibility (O'Shea et al., 2021). At each collection site, five random subsamples in one square meter were taken from the top 5 cm of soil using plastic spoons (O'Shea et al., 2021). They were then combined into a simple sample, which was homogenized in a polyethylene bag by shaking for five minutes (O'Shea et al., 2021). The dust and soil samples that contained the highest amount of lead were examined using SEM, which demonstrated that numerous Pb particles occur

in both road dust and soils (O'Shea et al., 2021). The study found that the Pb measured was largely derived from Pb paint and leaded gasoline (O'Shea et al., 2021). However, the soil samples showed how heavily polluted they were with lead. The mean concentrations of Pb in bulk and fine soils exceeded the EPA threshold (O'Shea et al., 2021). With many of the particles being micrometer to submicrometer-sized, the particles of lead can pose significant health risks.

Philadelphia faces a range of social and economic challenges, including elevated violent crime rates and long-standing issues related to environmental pollution. Violent crime is a

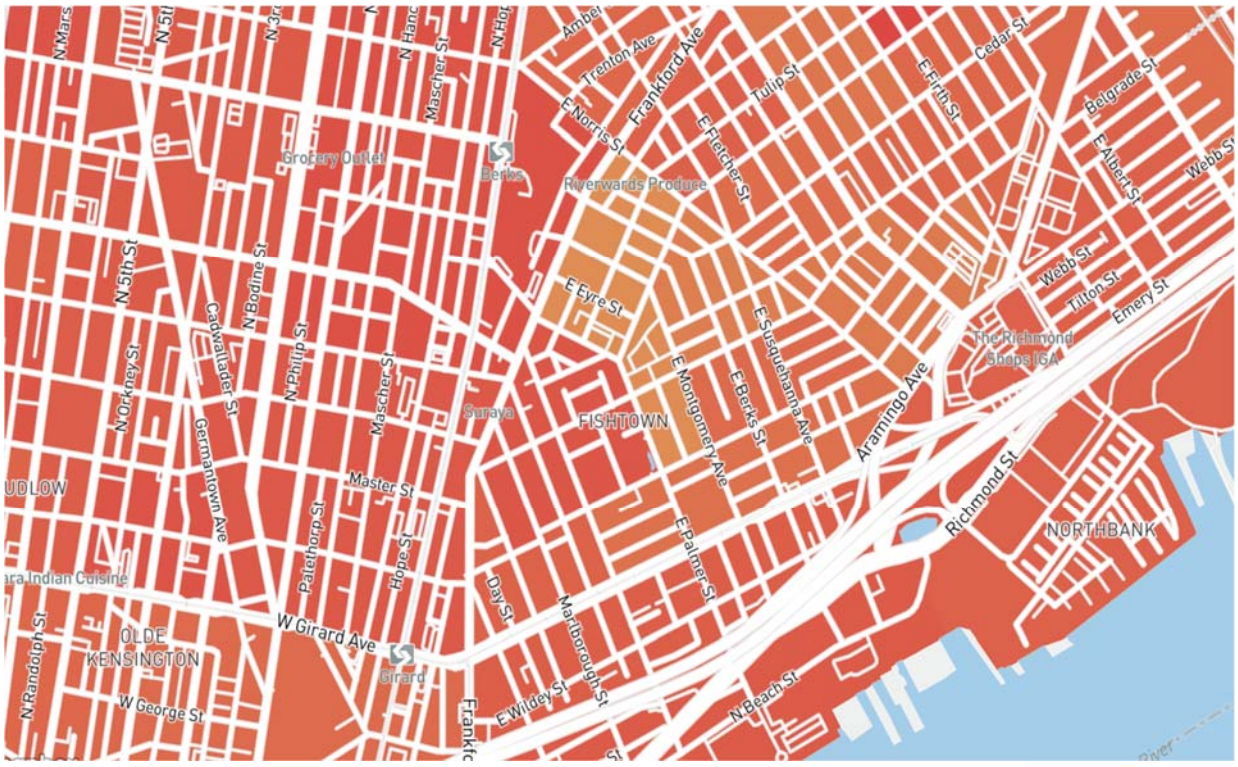

Fig. 3. Crime map of Fishtown, PA from crimegrade.org indicating the high crime rate in the area and surrounding areas.

significant concern. Using the FBI Data Explorer, the Philadelphia Police Department reported crimes that were compared to the national average of the United States. Beginning with

aggravated assault, it was high in comparison to the U.S. average, typically remaining at least twice the rate. Homicide, while not as high, still remained above the average at all times. Rape remained above the average at most times while robbery, never once was similar in comparison to the national average, remaining well above it.

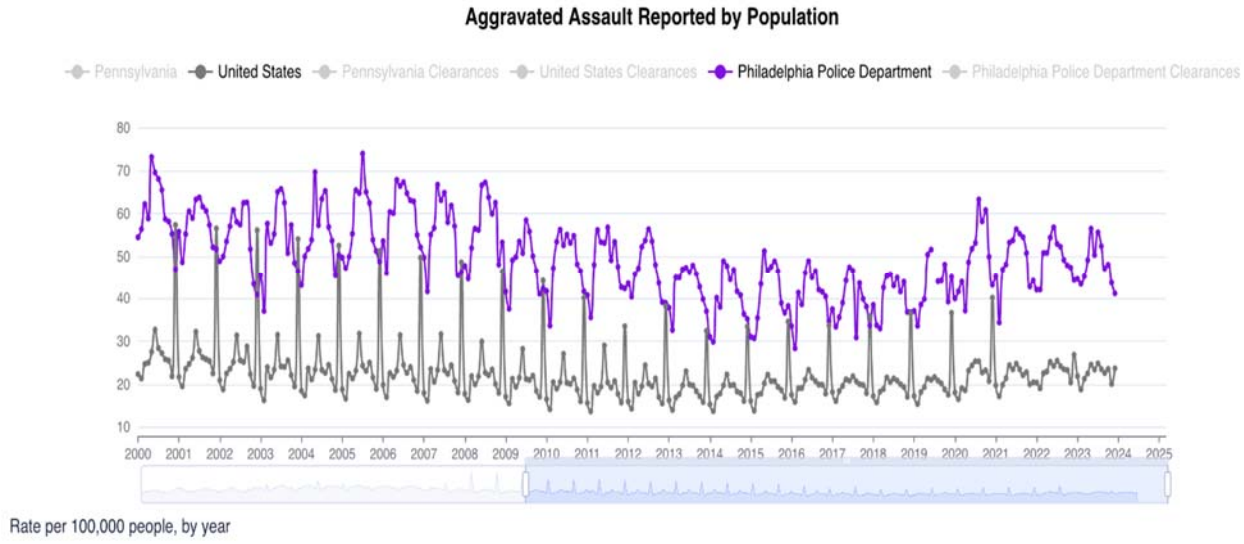

Fig. 4. Crime rates reported by the Philadelphia Police Department per 100,000 per year on aggravated assault from the FBI's Crime Data Explorer. This indicates the high volume of crime in Philadelphia compared to the United States as a whole showing this area is consistently more susceptible to violent crime for a period of over 20 years.

Las Vegas, Nevada

Las Vegas is one of the quickest-growing urban areas in the United States, making it a prime location for the authors to investigate potential environmental contaminants and pollutants in road sediment (Gokey et al. in review, 2024). There were 46 road sediment samples collected within the regions of Las Vegas, Henderson, and Boulder City; ten from North Las Vegas, ten from Boulder City, ten from Henderson, twelve from the Las Vegas Strip, and four from West

Las Vegas (Gokey et al. in review, 2024). Characterization of the samples used scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray fluorescence spectrometry (XRF) (Gokey et al. in review, 2024). In an area such as Las Vegas, road sediment can be exacerbated by the wind and environment, causing deleterious health effects (Gokey et al. in review, 2024). All samples were collected using plastic spoons and placing the material into clear plastic bags. Following this, all samples were dried for 24 hours to remove any excess moisture, then sieved using a brass sieve and placed into separate sample bags (Gokey et al. in review, 2024). The samples confirmed the presence of heavy metals and metalloids such as V, Ni, Cu, and Pb (Gokey et al. in review, 2024). A few of the Pb-bearing particles were larger in diameter than in previous investigations (Gokey et al. in review, 2024). A possible area of concern is that Nevada is one of the few states that has not banned leaded tire weights, making it a potential source of Pb in a high-traffic area (Gokey et al. in review, 2024). Without the long history of industrial activity, Pb present was lower in bulk concentrations than in other reported studies with an extensive industrial history (Gokey et al. in review, 2024).

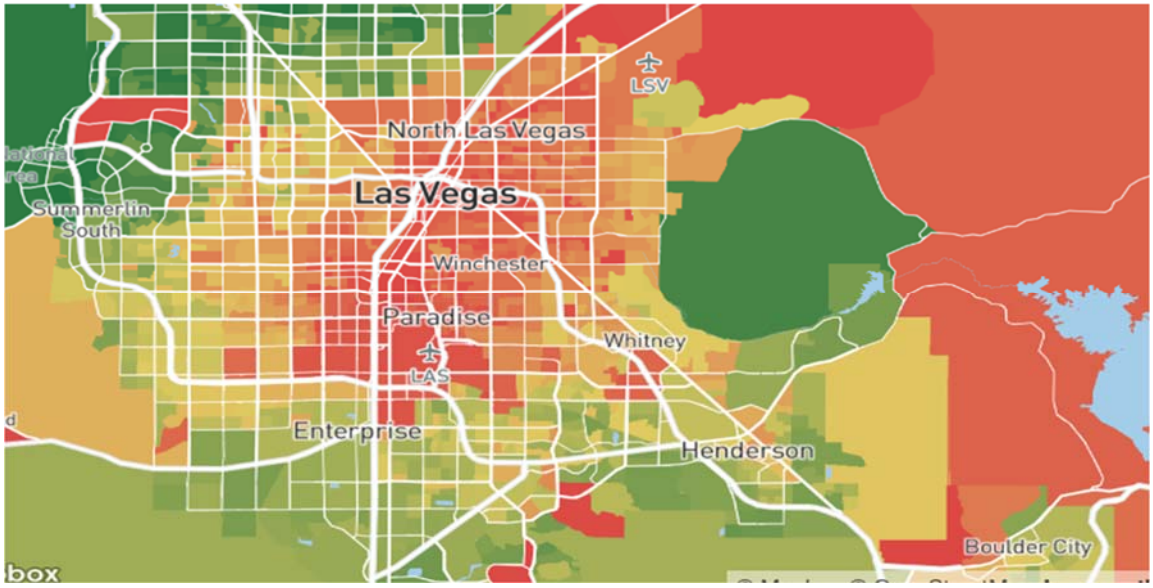

Fig. 5. Crime map of Las Vegas from crimegrade.org showing areas that are higher in crime in comparison to more safe areas.

Las Vegas is known for its tourist attractions and entertainment venues, while still facing a range of socio-economic challenges that contribute to the city's crime trends. According to the FBI Data Explorer, Las Vegas experiences relatively high violent crime rates. Aggravated assault began to rise in the early 2000s, eventually reaching above the national average, maintaining that. However, their homicide rates are usually above the national average, they remain relatively low in comparison to the other two cities explored. Rape is also consistently higher than the national average, although it appears to be on a downward trend. Robbery, also on a downward trend, is currently similar in rates to the national average; it was previously reported well above it.

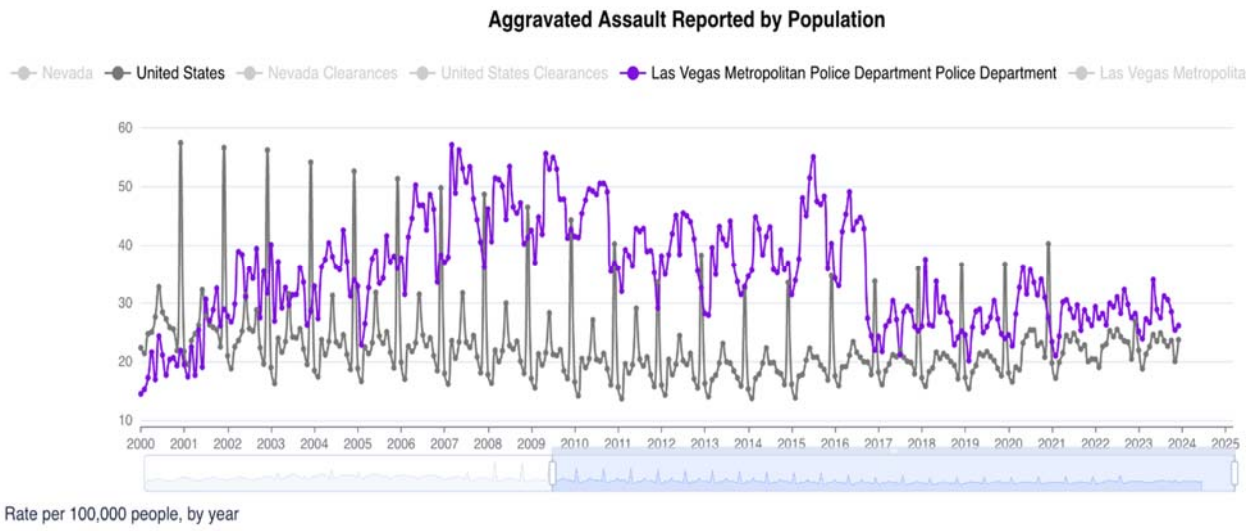

Fig. 6. Crime reports from the Las Vegas Metropolitan Police Department. The rate is cast as per 100,000 people since the year 2000. It is evident that the crime rate can vary.

Results

The preliminary findings from this study suggest that lead exposure may be a contributing factor to elevated crime rates in urban environments. By examining three cities- Gary, Indiana; Philadelphia, Pennsylvania; and Las Vegas, Nevada- we can identify potential correlations between lead contamination levels and crime trends. Gary, Indiana, is a city historically affected by industrial pollution, particularly its steel manufacturing plants. The road sediment in Gary contains elevated levels of lead as the concentrations are higher than in other cities as a result of industry. It is also known for its elevated crime rates, particularly in violent crimes such as aggravated assault and homicide. The city's high lead levels can exacerbate socioeconomic factors by impairing cognitive functions and increasing impulsivity among residents, particularly children. There is a potential correlation between lead exposure and high rates of violent crime, although other factors potentially play a significant role.

Philadelphia also has a long history of lead contamination due to industries such as smelting. The pollution contributing to the bulk and finer soil samples has been largely attributed to lead-based paint and gasoline for the past decades. High concentrations still persist in these neighborhoods, posing risks to their residents. Facing high levels of crime, areas such as Fishtown are subjected to the effects of lead exposure, which is potentially playing a significant role in the crime rate. Finally, Las Vegas, while not traditionally an industrial city, still shows elevated levels of lead. Although the concentrations are lower than those found in Gary or Fishtown, there is still a lead presence, especially in areas with high traffic. The correlation between crime and lead exposure is more difficult to establish in Las Vegas due to crime potentially being influenced by tourism. Lead exposure contributes negatively to the brain, resulting in delinquent behaviors.

Discussion and Limitations

The findings from this study suggest that lead exposure may contribute to elevated crime rates in urban environments, especially in Gary, Fishtown, and Las Vegas. While these insights provide important information for understanding potential relationships between environmental pollutants and criminal behavior, there are still several factors that need to be explored. A weakness of this study includes the fact that only potential links can be established rather than direct causation. This study can only offer correlations that suggest strong associations without offering evidence of causation. The complexities of urban environments, where many factors can influence crime, make it difficult to isolate the impact of lead exposure. However, the correlations observed between lead exposure and crime rates are heavily supported in previous research. As lead exposure can impair major cognitive functions, this can directly contribute to higher levels of violent crime. Areas of the brain responsible for regulating emotions and controlling behavior that are affected can help explain the impulsivity and aggression often seen in individuals with high levels of lead exposure, which increases the likelihood of violent behavior.

While lead exposure may be an important contributor to crime rates in certain areas, it is important to acknowledge that poverty, education, and access to healthcare, alongside other factors, play a significant role in influencing criminal behavior. Poverty limits opportunities and access to resources, which can increase the chances of engaging in criminal behavior. Additionally, educational disparities often lead to limited employment opportunities, which can lead to criminal behavior. While a lack of health care can worsen mental health problems, making certain individuals more prone to criminal activities.

Another limitation of this study is the reliance on convenience sampling for the selection of locations. This may not provide a fully representative analysis of broader urban areas. The focus on specific cities- Gary, Fishtown, and Las Vegas- limits the generalizability of the findings, as these locations were chosen based on available data rather than random sampling. As a result, the observed correlations may not necessarily apply to other regions with different socioeconomic and environmental conditions. Future research should aim to include a wider range of locations with varying lead exposure levels and crime rates to strengthen these findings.

Building on this scientific and social understanding of lead exposure's effects, it is also important to consider the legal implications of such environmental influences on behavior. Legal scholarship and case studies suggest that lead poisoning may have relevance in criminal proceedings both as a potential defense and as a mitigating factor in sentencing. Deborah Denno's analysis of the "Biosocial Study" in Philadelphia showed a strong correlation between childhood lead poisoning and later criminal behavior, including juvenile and adult offenses, as well as disciplinary problems in school (Denno, 1993). This has led some to argue that lead exposure, which causes neurodevelopmental impairments, to be comparable in legal terms to other factors that have previously supported insanity or diminished capacity defenses. While rarely raised or accepted in court, some of these comparable defenses have been successful, as in the case of Terrance Frank (Denno, 1993). His public defender contended brain damaged due to uranium-related radiation, resulting in him winning a temporary insanity defense (Denno, 1993). As for the defense of lead poisoning, it must be a defense of diminished capacity, leaving only three ways it could operate: "negation of mens rea, the defense of automatism, and involuntary intoxication from exposure to neurotoxins" (Kittilstad, 2018). Nonetheless, it is very difficult to pose a neurotoxin poisoning defense (Kittilstad, 2018).

However, more commonly, lead poisoning has been raised as a mitigating factor at sentencing rather than a complete defense. Eleanor Kittilstad argues it would be best considered as a contributing factor to delinquency that should be taken into consideration when determining a fair punishment (2018). As lead exposure reduces cognitive functioning, impulse control, and moral culpability, it should be formally recognized in sentencing across jurisdictions. Courts have already accepted neurological impairments as mitigating in death penalty cases. Given the amount of evidence linking lead to lifelong behavioral consequences, Kittilstad calls for it to be included in non-capital sentencing as well (2018). Doing so would align with the utilitarian and retributive goals of punishment which emphasize proportionate culpability (Kittilstad, 2018).

Conclusion

Lead exposure is a persistent public health issue, particularly in urban areas. It remains a significant public health concern, especially in areas with a history of industrial activity. In cities such as Gary, Fishtown, and Las Vegas, elevated levels of lead contamination, particularly in road sediment and soil, continue to pose serious health risks. The effects of lead exposure on cognitive function, brain development, and behavioral regulation are well-researched and documented, with children being especially vulnerable. Despite efforts to reduce lead levels, it still remains present in urban environments, often in disadvantaged communities, making public health challenges worse. The findings in this study suggest a correlation between elevated lead exposure and higher crime rates in urban areas. This is particularly evident in violent crimes.

This study contributes to the understanding of how environmental pollutants, specifically lead, may be linked to broader societal issues such as crime and public health. The findings suggest that environmental factors may play a role in shaping behaviors, more than previously thought. Understanding the impact of lead on cognitive and behavioral functions highlights the

need to consider the effects of environmental pollutants in discussions about criminal justice. It has important implications for public health, planning, and crime prevention. Recognizing the potential link between lead exposure and criminal behavior shows the need for more health initiatives that prioritize reducing lead contamination. Immediate steps should be taken in order to address lead exposure and combination in urban areas, particularly those with high-risk communities. Environmental testing and clean-up programs should be implemented, including lead removal initiatives. Additionally, community outreach programs should inform residents about the risk of lead exposure and help provide resources to test for lead in homes and in schools. Overall, there needs to be interventions in neighborhoods with the highest levels of contamination to reduce lead exposure and improve long-term health outcomes. It would be important for additional research to follow up on this and include larger sample sizes, particularly across different urban environments. Research should aim to control other factors such as socioeconomic status and access to education and healthcare to more effectively show the effects of lead exposure on criminal behavior. In conclusion, this study aimed to demonstrate a correlation between lead and delinquency while calling to action policymakers and individuals in the health field to be more aware of the effects of lead and to take decisive steps to address lead contamination in urban environments. By doing this, public health can be prioritized and work toward reducing crime and improving overall well-being. As research continues, it will be crucial to build on these initial findings and pursue more comprehensive research to mitigate the effects of lead and crime prevention and potentially establish causation with additional research.

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