Toxic structures: Speculation and lead exposure in Detroit's single-family rental market

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1 Introduction

Low-income residents in Detroit face a housing crisis. This crisis manifests in the cost of rent (Seymour and Akers, 2019), deteriorating structures (Dewar et al., 2015), speculative ownership practices (Akers and Seymour, 2018), and toxic housing (City of Detroit Health Department Task Force on Demolitions and Health, 2017). For those living in or near poverty these conditions are consistent throughout the city. Despite programs to maintain affordable housing and assist people facing foreclosure and eviction, the underlying conditions within these houses remain a threat to the most vulnerable populations in Detroit, particularly children. The age and decline in the city's housing stock leaves tenants with few options but to choose between toxic structures. The rise in bulk ownership and speculation in the city following the financial crisis makes it more likely these structures are under-maintained if maintained at all.

This study supplements our earlier report for Poverty Solutions on the operation of low-income housing markets in Detroit. This work examines one of these environmental hazards, childhood lead poisoning. We find three areas that increase a child's risk for lead exposure. The odds of exhibiting elevated blood lead concentrations are higher for children living in homes that were purchased in the Wayne County tax foreclosure auction. The highest risk is observed among children living in properties where the landlord owns 10 or more single-family properties obtained through tax foreclosure sale. We also find a relationship between nearby demolitions and blood lead toxicity.

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Tax foreclosure, bulk property ownership, and demolition offer three points of intervention to reduce the risk of lead poisoning in children. Bulk ownership and property speculation carry myriad social and public costs. These are particularly acute in Detroit and were exacerbated following the mortgage foreclosure crisis.[1] Over the last decade, there was a significant increase in bulk owners in the low-income housing market. In a number of cases, these owners milk properties (renting them without renovation or repair) until its dilapidated condition renders it useless. The house is then abandoned to tax foreclosure. Once the city takes possession, the public pays for its demolition.[2] Between the time bulk owners acquire then abandon a house, multiple evictions can occur. These activities carry significant downstream costs for residents seeking shelter. There are the environmental hazards present in these houses: lead, asbestos, mold, raw sewage in basements, poor ventilation and insulation, faulty mechanicals such as furnaces, or in some instances the lack of mechanicals. There are also the added stresses of financial instability and rental or contract agreements with high penalties for late payments and that place the responsibility for maintenance and upkeep on tenants (Akers and Seymour, 2019). Finally, the looming threat of eviction and its occurence push families further into poverty making it more costly to find housing, jobs, and remain healthy (Desmond and Kimbro, 2015).

This study situates the increased risk of lead exposure within the cycle of foreclosure, speculation, eviction, and demolition. In Detroit, the Wayne County tax foreclosure auction is the primary venue for bulk owners to purchase investment properties. We find that children are more likely to be lead poisoned and face eviction while living in a home owned by a landlord with 10 or more tax-foreclosed properties. As we document in our previous report, properties known to have been owned by speculators, many acquired through the annual tax auction, were subsequently demolished—principally after another tax foreclosure channeled them to public inventories. We estimate 16% of publicly funded residential demolitions between 2015 and April 2019 occurred on structures owned by a speculator at some point in the last decade. In this report, we find evidence consistent with the findings of the 2017 Detroit Health Department study that publicly-funded demolitions are associated with increased risk for childhood lead exposure.

The results of this study suggest that structural and systemic changes can reduce the risk of children being poisoned by lead in Detroit. Critical points of intervention lie outside of the health care system and extend beyond the simple maintenance of home interiors. A holistic approach would include actions that limit the supply of these properties to bulk owners, an increased emphasis on lead inspections and remediation that targets landlords most likely to hold multiple toxic structures, extending eviction protections for those most at risk, and more effective management of dust and run-off from demolitions. Nearly all of these, except for tenant protections, are possible under existing policies and ordinances.

This report focuses on Detroit, but the risk of lead exposure is an issue for children in cities across Michigan. In 2016, 8.8% of Detroit children under 6 screened for lead poisoning

[1] See Akers and Seymour (2019) for a more detailed examination of the housing life cycle from foreclosure, to eviction, to demolition.

[2] Since 2014, the City of Detroit has expended $34 million tearing down bulk buyer and speculator homes abandoned through tax foreclosure (Akers and Seymour, 2019).

exhibited blood lead concentrations equal or greater than the CDC's reference value of 5 micrograms of lead per deciliter of blood (μg/dL), hereafter referred to as elevated blood lead levels (EBLLs). Exposure rates over 8% were also found in Adrian, Grand Rapids, Hamtramck, Highland Park, and Jackson. In Highland Park the rate was 14% in 2016. For comparison, in that same year, the lead poisoning rate in Flint was 2.4% (Childhood Lead Poisoning Prevention Program, 2017a). This is not to diminish the negative impacts of Flint's ongoing water crisis, but to illustrate the extreme risks faced by Michigan children, particularly those living in low-income neighborhoods. Research in public health continues to demonstrate that risks to children's health are primarily borne by low-income communities of color in urban neighborhoods. Public health response to lead exposure is primarily reactive with intervention and environmental remediation coming after a child is poisoned. By examining the role of toxic structures and analyzing where potential risks are greater, particularly in the process of public property disposition, we are able to identify points of intervention that could limit exposure to risk prior to a child's positive test.

In cities like Detroit with an aging and deteriorating housing stock and prolonged disinvestment, particularly in older single-family residential neighborhoods, the prevalence of lead-based paint carries significant risks to children's health and a significant cost for remediation. Lead dust generated through the friction of opening and closing windows and doors and the ingestion of paint chips are the primary factors in exposure. The higher costs of full remediation means that encapsulation, i.e., regularly painting over with latex-based paint, is a method of limiting exposure (Breysse et al., 2007). Rental housing in these areas accounts for a higher number of cases of lead poisoning. Both the age of the house and the lack of maintenance and upkeep increase this risk (Jacobs et al., 2002; Lanphear et al., 2005). Research on the practices and approaches of landlords operating in low-income housing markets have documented deferred maintenance as a way to increase or to maintain profitability (Desmond, 2016; Seymour and Akers, 2019; Sternlieb, 1969). Whether these are the actions of small-scale "mom and pop" operations trying to stay afloat or the class of bulk owners and speculators that expanded operation after the financial crisis, the risks of toxic structures are borne by those living in them while profits, however large or small, are made in not maintaining a safe or healthy structure.

Detroit is now a majority renter city (Akers and Seymour, 2018). A city once renowned for its high level of homeownership, particularly Black homeownership, saw massive changes to these patterns following the mortgage crisis and subsequent waves of tax foreclosure. Over the past decade there was an influx of bulk buyers purchasing large volumes of property out of mortgage and tax foreclosure. These foreclosure buyers operate in the residential market and as wholesale suppliers to residential landlords. These landlords and speculators use a variety of tactics to find and place tenants in these properties including land installment contracts and lease purchase agreements that portend to offer buyers home ownership while placing the burden on maintaining aging houses on tenants. These types of contracts often end in failure. These structural changes to low-income housing markets result in a greater likelihood of eviction, but also a higher risk of lead exposure for children. Both eviction and lead poisoning carry long-term impacts on health and well-being, access to opportunity, and life outcomes. The current life cycle of low-income housing in Detroit places the city's most vulnerable populations in harms way. These risk and harms can be accounted for in our current system of property disposition from foreclosure to speculative purchase to eviction and eventual demolition. As these are processes handled by public agencies, there are multiple points for intervening before exposure occurs.

2 Background

Despite substantial declines in blood lead concentrations in U.S. children over the past four decades, trenchant disparities in childhood lead poisoning remain delineated by race, class, and geography. The most severe risk of lead poisoning is among Black children and those living in low-income urban neighborhoods where a high proportion of the housing stock was built prior to the banning of residential lead-based paint in 1978 (Jain, 2016; Krieger et al., 2005; Vivier et al., 2011; White et al., 2016). Lead in house dust from deteriorated and disturbed paint is the principal source of toxicity for most children (Dixon et al., 2008; Gaitens et al., 2008). Children under the age of 6 are especially vulnerable to lead poisoning because they ingest lead more readily through normal hand-to-mouth activity and absorb lead more efficiently than older children and adults (Bearer, 1995). Further, the toxicological effects of lead poisoning are particularly damaging during early childhood when the brain and central nervous system are undergoing rapid development (Lidsky and Schneider, 2003).

The consequences of excessive exposure to lead are grave and enduring (Needleman, 2004; Patrick, 2006). No safe level of lead contamination exists, as accruing evidence implicates even low-level, asymptomatic blood lead concentrations (<5 μg/dL) as a causal risk factor for a range of adverse and long-term effects, not limited to cognitive and intellectual deficits, developmental delays, neurobehavioral disorders, reduced academic achievement, hypertension, and renal impairment (AAP Council on Environmental Health, 2016). At very high exposure levels, lead can result in seizures, coma, and death (Staes et al., 1995). There are no effective treatments to mitigate the irreversible effects of lead toxicity, and public health response is largely restricted to secondary prevention screening programs that remediate home-based lead exposure hazards only after a child has already been poisoned (Lanphear, 2005).

Lead safety is primarily a function of how property owners maintain houses that contain lead paint (Ryan et al., 1999). While the prevalence of lead-based paint in U.S. housing remains high, not all of it is hazardous (Jacobs et al., 2002).[3] Research has demonstrated the effectiveness of safe lead management practices and hazard reduction standards (Brown et al., 2001; Etre et al., 1999), and there is evidence to suggest that poor paint condition is more strongly associated with exposure risk than the paint's lead content (Lanphear et al., 1996). Since the implementation of lead safety regulations in federally owned and assisted housing in the early 2000s (24 CFR Part 35), risk for lead exposure in low-income housing has been mostly concentrated in older, privately-owned, single-family rental properties in

[3] The American Healthy Homes Survey (AHHS) estimates that lead-based paint is present in approximately 37.1 million homes (35% of 106 million total housing units); 23.2 million homes (22%) are thought to contain lead-based paint hazards (U.S. Department of Housing and Urban Development, 2011).

poorly maintained condition (Ahrens et al., 2016; Dewalt et al., 2015; Jain, 2016).

In the private market, federal protections are limited to disclosure rules that require owners to report any known lead-based paint and/or lead hazards upon sale or lease of pre-1978 residential property (Brown, 2002).[4] This narrow provision, however, allows hazards to persist so long as they remain unidentified (Korfmacher and Hanley, 2013). A tenant's request for a home inspection or needed repairs can cause a landlord to come under increased state scrutiny or incur unwelcome costs, leading to further negligence or prompting retaliatory eviction (Desmond et al., 2013). Especially in cities with large quantities of high-risk housing stock, resource constraints limit the ability of state and local health departments to enforce lead safety controls in hazardous properties that are known to house lead-poisoned children (Brown, 2002). Having already made the forced choice between housing quality and cost, precariously housed low-income families can easily face a dilemma over whether to remain in unhealthy housing or move, at significant cost, to risk ending up in similar or worse conditions (Bashir, 2002).

Although few scholars have investigated how ownership patterns may influence the distribution of lead exposure risk in low-income housing markets with high volumes of pre-1978 structures, evidence from several cities with high lead poisoning rates indicates that a small number of properties (and property owners) have been responsible for a significant percentage of total lead poisoning cases over time. For instance, a 2006 study by Reyes et al. (2006) found that 67 "high-risk" buildings (0.2% of the building stock) in Chicago were associated with a total of 994 children diagnosed with lead toxicity between 1997 and 2003 (2% of all lead poisoned children). In Jefferson County, Kentucky (home to Louisville), 79 homes housed 35% of the children with blood lead concentrations 20 μg/dL or greater. In Rochester, New York, Korfmacher and Kuholski (2007) investigated whether a discrete number of properties accounted for multiple lead-poisoned children over a ten-year period, finding that 14% of properties with repeat violations had become publicly owned (primarily due to tax foreclosure) during the study period, the majority of which were subsequently demolished. These findings indicate that patterns of systemic neglect brought by a subset of property owners in low-income housing markets can disproportionately contribute to toxic disease burdens in high-risk communities.

It follows that changes to low-income property markets following the financial crisis threaten to exacerbate already staggering risk disparities in lead-polluted residential environments. Weak-market cities with high concentrations of older, deteriorating homes have now seen many properties go through a familiar cycle (or several) of abandonment, foreclosure, and speculative ownership, rapidly degrading property conditions. Mortgage and tax foreclosure pipelines have expanded the "disclosure loophole" (Korfmacher and Hanley, 2013, pg. 808), as federal laws do not require information on the presence of lead hazards to be conveyed through foreclosure proceedings (Department of Housing and Urban Development and Environmental Protection Agency, 1996). The forced displacement of owner-occupied

[4] State and local policies vary markedly, but proactive inspection and control requirements for rental properties are rare and often poorly enforced (Brown, 2002). Most consist of education and selective grant programs that place the burden of identifying lead hazards on tenants and which require landlords to comply and usually pay for costly risk assessments and abatement procedures.

households has increased the number of families in search rental housing, while its supply has become increasingly dominated by large investor-landlords. The increased inventory of these bulk buyers has led to a series of practices that have negative impacts on the local housing stock and on occupants. This paper examines toxic lead exposure as a potential human cost of these speculative property relations.

3 Detroit Context

While the problem of lead exposure is national in scope, lead-based paint hazards are most prevalent in the Northeast and Midwest (Dewalt et al., 2015), particularly in older industrial cities with large Black populations (Lively, 1993).[5] This trend is apparent in Michigan, which, despite experiencing a state-wide lead exposure prevalence similar to the national average, includes several cities that have historically borne a disproportionate burden of the state's lead exposure risk.[6] Michigan's Childhood Lead Poisoning Prevention Program (CLPPP) monitors lead poisoning events in nine cities where a larger proportion of the housing stock was built before 1950 (ranging from 33.2 to 69.6%) and before 1980 (ranging from 77.0 to 92.3%) than the state as whole (23.1 and 65.8%, respectively) (Childhood Lead Poisoning Prevention Program, 2017a). Combined, these nine "targeted communities" contain 12% of the state's total population but half (50.7%) of its black population (US Bureau of the Census, 2016).[7] The highest prevalence of lead poisoning persists in Highland Park, a city where 91.9% of residents are black and where lead toxicity was detected in 14.0 to 15.9% of tested children between 2013 and 2016.

In terms of the number of children impacted, the city of Detroit bears the state's largest lead exposure burden (Childhood Lead Poisoning Prevention Program, 2017a). Detroit is a city of predominantly older, single-family housing where about 60% of children live below the poverty line. In 2016 alone, 2,073 Detroit children under the age of 6 screened for lead demonstrated EBLLs, demonstrating an incidence rate 2.4 times the state average (8.8% vs. 2.6% of those tested) and accounting for more than one-third of all young children in state with EBLLs (Childhood Lead Poisoning Prevention Program, 2017a). Of the 17 Michigan ZIP codes in 2016 where more than 10% of all tested children demonstrated EBLLs, 10 were located in Detroit; in one ZIP code, 22% of all children experienced toxic levels of lead contamination, the highest in the state (Childhood Lead Poisoning Prevention Program, 2017b). Among the nine most heavily lead-polluted cities in Michigan, Detroit was one of only two that experienced a rise in the percentage of EBLL in tested children between 2013 and 2016.[8]

The consequences of this burden for the well-being of Detroit's children is far from fully

[5] The CDC estimates that nationally 535,000 children age 1-5 (2.6% of children in this age group) have EBLLs (Wheeler and Brown, 2013).

[6] In 2016, 5,724 children under age 6 (3.6% of all children under 6 tested) had blood lead levels ≥ 5 μg/dL (Childhood Lead Poisoning Prevention Program, 2017a).

[7] Targeted communities (and associated EBLL prevalence rates in 2016) include: Adrian (8.4%), Detroit (8.8%), Flint (2.4%), Grand Rapids (8.1%), Hamtramck (8.1%), Highland Park (14.0%), Jackson (8.4%), Lansing (3.3%), Muskegon (7.7%) (Childhood Lead Poisoning Prevention Program, 2017a).

[8] The other city is Hamtramck, which is surrounded by the city of Detroit.

known. Zhang et al. (2013) linked blood lead testing surveillance data with standardized test score data for students in Detroit public schools to assess the long-term effect of early childhood lead exposure on academic achievement in elementary and junior high schools (grades 3, 5, and 8). After adjusting for potential confounders, the authors found the odds of scoring "less than proficient" for those whose blood lead levels 10 μg/dL or higher before the age of 6 were more than twice the odds for those whose blood lead levels were under 1 μg/dL. This study offers insight on just one of the many cascading downstream effects of this structured inequality on the future life chances of Detroit's children.

An analysis of American Community Survey (ACS) Public Use Microdata Samples (PUMS) (Table 1) shows that 90% of Detroit children age 6 and under reside in housing built in 1979 or earlier and 57% of those are in housing built prior to 1950 when lead concentrations in paint were significantly higher. This suggests many of the city's young children live in housing units highly likely to have lead paint. Fully 78% of the children analyzed in this table, regardless of housing age, are Black, indicating the clear racial dimension of risk of lead exposure in Detroit. A focus on single-family detached housing (Table 2) shows that 77% of children 6 and under are in that type of home; 86% of these children live in 1-family housing, either attached or detached. Most (60%) children in single-family detached housing live in renter households. Among children in renter households in single family detached housing, 96% live in units built in 1979 or earlier. The comparable figure for children in owner occupied housing is 95%. Hence, the population most vulnerable to lead exposure lives in precisely the types of properties at-risk of tax foreclosure and resale to problem investors and speculators.

Table 1: Children 6 years or younger by age of structure, Detroit, 2013–2017

Year built	n	pct.	cum. pct.
1939 or earlier	21,979	33.4	33.4
1940-1949	15,742	23.9	57.4
1950-1959	14,837	22.6	79.9
1960-1969	3,970	6.0	86.0
1970-1979	2,757	4.2	90.2
1980-1989	1,241	1.9	92.1
1990-1999	2,002	3.0	95.1
2000-2009	3,043	4.6	99.7
2010-2016	169	0.3	100.0

Source: American Community Survey 2017 5-year estimates Public Use Microdata Sample (PUMS) (Ruggles et al., 2019).

Note: Includes children living in Public Use Microdata Areas (PUMAs) where the majority of respondents live in the city of Detroit.

Table 2: Children 6 years or younger by units in structure, Detroit, 2013–2017

Units in structure	n	pct.	cum. pct.
1-family house, detached	50,763	77.5	77.5
1-family house, attached	5,433	8.3	85.8
2-family building	3,281	5.0	90.8
3-4 family building	1,186	1.8	92.6
5-9 family building	1,483	2.3	94.9
10-19 family building	1,015	1.5	96.5
20-49 family building	1,088	1.7	98.1
50+ family building	1,236	1.9	100.0

Source: American Community Survey 2017 5-year estimates Public Use Microdata Sample (PUMS) (Ruggles et al., 2019).

Note: Includes children living in Public Use Microdata Areas (PUMAs) where the majority of respondents live in the city of Detroit. Excludes children living in mobile homes or trailers.

4 Data and Methods

To test the relationship between speculator ownership and elevated blood lead levels in children, we linked records of venous blood tests reported to the Michigan Department of Health and Human Services CLPPP[9] between January 1, 2014 and December 30, 2017 to a variety of property ownership and transaction records based on the parcel identification number common to both data sources.[10] To remove duplicate records and include distinct individuals just once in our analysis, we restricted the blood test data to the earliest test date for a given individual, which, in the absence of personal identifiers, we approximated by grouping observations based on parcel identification number, age, and sex. Each test contains the observed blood lead level, which we classify into a binary variable distinguishing between values of at least 5 μg/dL (EBLL) and all lower values.

[9] It is important to note that the universe of blood test results used for this analysis is not representative of all Detroit children; between 2014 and 2016, roughly 40% of Detroit children under age 6 were tested. While Michigan's public health code (MCL 333.20531) mandates reporting for all blood lead test results, blood lead surveillance is focused on children at the greatest risk for lead poisoning. Michigan law (MCL 400.111k-l) requires that all children enrolled in Medicaid and/or who receive WIC nutrition services receive lead testing; in Wayne county in 2016, about 75% of children under 6 tested for lead were enrolled in Medicaid (data for Detroit is unavailable) (Childhood Lead Poisoning Prevention Program, 2017a). Still, significant testing gaps remain as a result of under-enrollment in public programs and under-testing among program participants. Hence, we cannot eliminate the possibility that selection bias and residual confounding stemming from the the sample's over-representation of children from low-income families (and under-representation of children disconnected from the health care system) may influence our results. However, as this population is presumably more likely than children from more advantaged backgrounds to reside in the low-quality rental housing, we are better able to examine variation in lead poisoning outcomes within this population that may be attributable to tax foreclosure purchasing and speculative property ownership. We further attempt to reduce the role of socioeconomic confounding by controlling for factors including property value and neighborhood-level poverty status and by restricting our sample to renter-occupied properties.

[10] EBLL data was provided the Detroit Health Department.

Our independent variable of interest, speculative property ownership, is derived from records of property acquisitions at the annual Wayne County tax foreclosure auction. We obtained records of post-auction property transfers from the Wayne County Treasurer to third-party buyers for 2005 to 2015, and we supplemented these with 2016 tax auction results tracked by Loveland Technologies, a private data vendor with direct access to online auction bidding activities. We hypothesize speculators purchasing large numbers of properties at auction are less likely to maintain their acquisitions and undertake lead remediation actions. Thus our intent is to test whether children living in properties purchased by successively larger investors are increasingly more likely to exhibit EBLL relative to properties *not* purchased at auction. We code auction investors into three categories: (1) those buying between 1 and 9 properties 2005–2016, (2) those buying between 10 and 49 properties, and (3) those buying 50 or more properties. Though investors account for the vast majority of tax auction purchases, a non-trivial number of properties have been purchased by the City of Detroit and quasi-governmental entities, including the Detroit Land Bank Authority. We exclude these purchases from our investor classification. We further exclude purchases by the United Community Housing Coalition, which frequently buys properties on behalf of occupants facing foreclosure. We include these types of non-investor auction acquisitions with properties not purchased at auction in the reference category.

To establish temporal order between the property's acquisition through tax foreclosure and the child's subsequent blood lead level, we selected the most recent auction sale prior to the specimen collection date for properties with multiple auction events. As blood serves as the body's initial repository for absorbed lead (before it is either stored in soft tissues and bone or excreted), blood lead tests tend to correlate most closely with recent environmental exposure. Although lead that is stored in the blood can be eliminated within several weeks, elimination times vary with age and exposure history (Agency for Toxic Substances and Disease Registry, 2007). In children, chronic exposure to lead from both internal (e.g. bone) and external sources can cause BLLs to remain elevated for longer durations (Manton et al., 2000). Dignam et al. (2008) found that children enrolled in case management with BLLs ≥ 10 μg/dL required slightly more than 1 year for their BLLs to decline to less than 10 μg/dL. While our analysis cannot eliminate the possibility that EBLL may precede residence in a speculator-owned house, blood lead measurements provide the most reliable available estimate of recent and ongoing exposures within the home.

To control for property characteristics, particularly home age, we join each year of blood test data to property assessor data corresponding to the same year based on parcel identification number. From these assessor data, we retrieve the year the property was built, assessed value, property class (e.g., commercial, residential), and latitude and longitude coordinates. To calculate home age, we subtract the year the housing unit was built from the year of the test. We drop all observations we were unable to join to assessor data or from which we were unable to obtain the year the housing unit was built. For assessed value, we use the State Equalized Value (SEV), which is based on 50% of market value as required by state law. Though these values may be subject to inflation in some parts of the city, they are the best available proxy for property values.

As proximity to recent demolitions is associated with EBLL (Farfel et al., 2003; Rabito et al., 2007), we control for exposure due to nearby demolitions drawing on records of demolitions completed in Detroit from January 1, 2014 to April 11, 2019. For each case in our sample with a test occurring on or after March 1, 2014, we count the number of demolitions occurring within 400 feet of the property in which the child resided and up to 45 days prior to the specimen collection. The 400-foot radius approximates the dispersion zone for lead dust from a demolition assuming dust suppression techniques like wetting (Jacobs et al., 2013), while the 45-day period reflects the half-life of lead in the blood (Rabinowitz et al., 1976).

As nearby vacant properties, particularly in communities with older housing stock, are also associated with increased lead exposure (Lanphear et al., 1996; Sayre and Katzel, 1979), we proxy for the number of nearby vacant properties by including the count of those located within 200 feet of test subjects' residence and up to 365 days after specimen collection date. We classify both past and future demolitions into three levels: 0 demolitions, 1 demolition, and 2 or more demolitions given their likely non-linear relationship to blood test levels.

We further adjust our models for individual and neighborhood covariates related to blood lead levels in children. Blood test records provide data on the child's sex, birth date, and date of specimen collection. We include the child's sex as a dummy variable, with males as the referent category. As blood lead concentrations tend to peak between ages one and three (AAP Council on Environmental Health, 2016), we include a categorical control variable of age (in years) at the time of testing, obtained by taking the difference between the child's birthday and the specimen collection date. In addition to controlling for year of test, we account for seasonal variation in blood lead concentrations (Levin et al., 2008) by including month of test as a categorical covariate. As socioeconomic data on the child's family is not available, we employ census tract-level poverty as a spatial proxy (Moody et al., 2016), a measure which has consistently detected the strongest socioeconomic gradient in prior research on childhood lead poisoning (Krieger et al., 2003). Additionally, we control for unobserved spatial variation in environmental exposure to lead with a vector of fixed effects constructed by classifying the 31 zipcodes fully within or intersecting Detroit into five districts.

As investor ownership is closely linked to housing tenure, we also code the properties in which children reside as likely renter-occupied based on several data sources. First, for each test year, we join each child's housing unit to property assessor records for the same year based on the parcel identification number. We check first whether the taxpayer address is located outside Detroit, coding those properties as likely renter-occupied, and, where that condition fails, we then check whether the property street number is identical to the street number for the taxpayer address. Where the street numbers are not identical, we code those observations as involving renter-occupied housing. We additionally classify all properties purchased at auction prior to the specimen collection date as renter-occupied. Lastly, we classify properties as renter-occupied if, for a given year in which specimens were collected, the properties in which children are living are classified as speculator-owned by Property Praxis.

Using these data, we estimate a series of logistic regression models, taking the binary outcome of EBLL as our dependent variable. We estimate two models including all specimens collected from children living in residential properties. Given the possibility that investor acquisition is likely associated with renter occupancy, we estimate two further models restricting our sample to likely renter-occupied properties, as defined above.

5 Results

Table 3 presents descriptive statistics. The average blood lead level across our full sample is 2.18 μg/dL, well below 5 μg/dL, the threshold we use to indicate EBLL. A one standard deviation increase above the mean is still just below this threshold, at 4.75 μg/dL. Thus exhibiting EBLL in our sample is a relatively infrequent occurrence. The average age of the housing in which the children in our sample live is 80 years. Children exhibiting EBLL live in somewhat older housing, with an average age of 88 years (see Figure 1 for scatterplot of home age and BLLs). The average values for past and future demolitions are both quite low, but the mean values are higher for both variables for children exhibiting EBLL than the other children in our sample. The average poverty rate for the neighborhood is quite high, nearly 40% for all children, with little difference between those exhibiting EBLL and those who do not. Lastly, we see that there is a modest association between rentership and EBLL, with 60% of children likely living in rental housing exhibiting EBLL compared to 54% for those who do not. Though not presented in the table, for properties sold at auction, the median time between auction and specimen collection is close to two years.

Table 3: Descriptive statistics

	EBLL = No		EBLL = Yes		All	
Variable	mean	std	mean	std	mean	std
Blood lead (μg/dL)	1.64	0.84	8.44	5.58	2.18	2.55
Male[a]	0.49	–	0.44	–	0.49	–
Age in years	2.93	1.52	2.82	1.33	2.92	1.51
Home age	80.19	14.76	87.95	13.69	80.81	14.82
SEV[b]	10.72	4.41	10.31	4.80	10.69	4.44
Past demolitions	0.10	0.49	0.15	0.66	0.10	0.50
Future demolitions	0.17	0.53	0.23	0.64	0.18	0.54
Poverty rate	38.30	10.61	39.79	10.84	38.42	10.63
Likely rental[a]	0.54	–	0.60	–	0.55	–
Observations	35,173		3,030		38,203	

[a] Mean values indicate proportion of cases in named category, e.g., proportion male
[b] In thousands of dollars
Note: Restricted to sample included in Models 1 and 2 and presented in Table 6, e.g., only children under 6 years of age living in residential properties.

Table 4 shows the association between our categorical variables for recent nearby demolitions and EBLL. These descriptive results conform to our expectation that the likelihood of exhibiting EBLL increases with each successively higher level of our ordinal variables capturing demolitions. Roughly 13% of the children living in properties near two or more

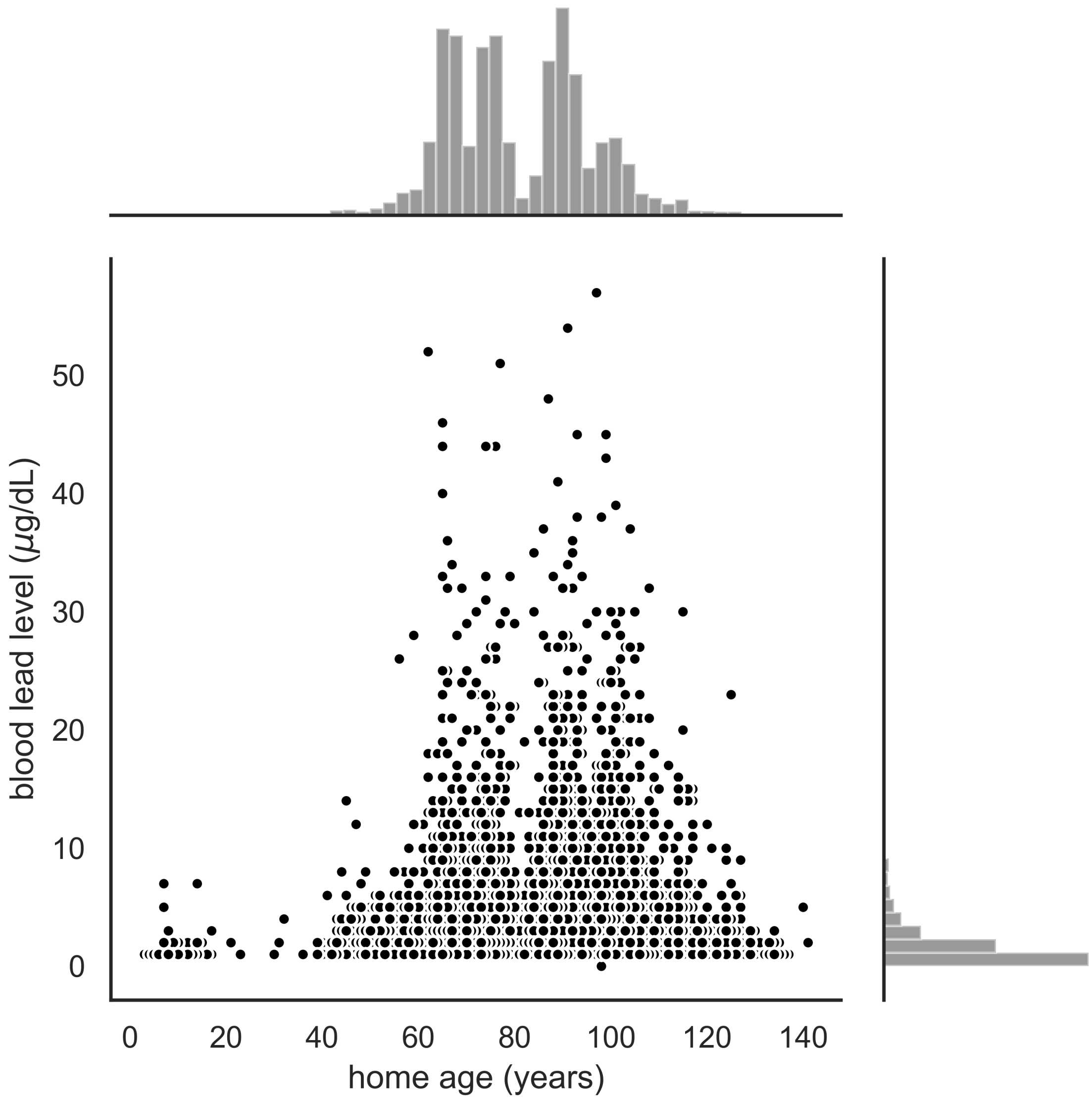

Figure 1: Association between home age and blood lead levels. Note: Restricted to sample included in Models 1 and 2 and presented in Table 6, e.g., only children under 6 years of age living in residential properties. Horizontal and vertical bar graphs are histograms of home age and blood lead level, respectively.

recent demolitions exhibit EBLL compared to less than 8% of the children not living near any recent demolitions. These relationship largely persist after restricting our sample to likely rentals, though the differences between each level of our ordinal demolition variables is reduced. The difference between living near two or more recent demolitions and not living near any recent demolitions changes to 10.4% of children exhibiting EBLL compared to 8.5%, respectively. Additionally, the odds of exhibiting EBLL are higher for children living near one demolition compared to two or more in this restricted sample. These results are similar for future demolitions, which we use to proxy for nearby vacant properties at the time of specimen collection, with each increasing level of the demolition category associated with higher odds of EBLL in both the full and restricted samples.

Table 4: Elevated blood lead status by recent nearby demolitions

	Number of nearby demolitions[a]							
	0		1		2+		All	
EBLL	n	%	n	%	n	%	n	%
No	33,012	92.23	1,565	90.67	596	87.26	35,173	92.07
Yes	2,782	7.77	161	9.33	87	12.74	3,030	7.93
All	35,794	100.00	1,726	100.00	683	100.00	38,203	100.00
Sample restricted to children likely living in rental units								
No	17,815	91.48	881	89.17	354	89.62	19,050	91.34
Yes	1,659	8.52	107	10.83	41	10.38	1,807	8.66
All	19,474	100.00	988	100.00	395	100.00	20,857	100.00

[a] Demolitions occurring within 45 days prior and 400 feet from test property.

Note: Restricted to samples included in Models 1–4 and presented in Table 6, e.g., only children under 6 years of age living in residential properties.

Table 5 shows the association between the categorical variables of EBLL status and tax auction investor size. It shows that the baseline odds of exhibiting EBLL are 3,030:35,173, with roughly 8% of all children under the age of 6 in our full sample exhibiting EBLL. Baseline odds are slightly higher in the more restrictive sample (1,807:19,050), which is reduced to blood tests for children living in housing units determined to be likely renter-occupied. For both samples, the odds of exhibiting EBLL is higher for each level of the investor category, with the exception of the smallest investor category in the sample restricted to renter households. In this case, the odds for this smallest level of our investor category are slightly smaller (0.0877) than the odds for our reference category (0.0921). The two highest levels of the investor category, however, exhibit higher odds than either the lowest investor category or the reference category.

Table 6 shows the results of our regression analyses. Model 1 is our baseline model for all specimens collected from children living in residential properties, nearly all of which are single-family detached housing units. In all models, we restrict our sample to children under 6 years of age, the population most susceptible to the long-term negative effects of lead

Table 5: Elevated blood lead status by auction investor category

	Investor category[a]								All	
	0		1–9		10–49		50+			
EBLL	n	%	n	%	n	%	n	%	n	%
No	29,408	92.32	1,197	91.94	1,922	90.40	2,646	90.59	35,173	92.07
Yes	2,446	7.68	105	8.06	204	9.60	275	9.41	3,030	7.93
All	31,854	100.00	1,302	100.00	2,126	100.0	2,921	100.00	38,203	100.00
Sample restricted to children likely living in rental units										
No	13,285	91.57	1,197	91.94	1,922	90.40	2,646	90.59	19,050	91.34
Yes	1,223	8.43	105	8.06	204	9.60	275	9.41	1,807	8.66
All	14,508	100.00	1,302	100.00	2,126	100.0	2,921	100.00	20,857	100.00

[a] Levels of category refer to number of residential properties purchased at annual Wayne County tax auction 2005–2016. The first category, 0, indicates blood tests for children not residing in a property purchased at the tax auction 2005–2016.

Note: Restricted to samples included in Models 1–4 and presented in Table 6, e.g., only children under 6 years of age living in residential properties.

exposure. As expected, we observe that home age is positively associated with the odds of exhibiting an EBLL. Male children are also predicted to exhibit higher odds of EBLL compared to female children. Higher home values (SEV) are negatively associated with the odds of exhibiting EBLL. Location near a single recent or future demolition is not associated with a higher odds of EBLL, but larger numbers (2+) of both past and future nearby demolitions are positively associated with the odds of exhibiting EBLL. Lastly, the share of population below poverty is positively associated with exhibiting EBLL.

Model 2 expands on Model 1 by including our central predictor of interest: ownership by tax auction investor by size of investment activity. Results indicate that each level of this variable increases the odds of EBLL relative to the reference category of not being purchased by an investor at auction. The odds ratio for the second auction buyer category (10–49 homes) is larger than the first category, as expected, but the highest category (50+ homes) is marginally smaller than the second category, though the two are not statistically significantly different from each other, as determined by changing the reference category for the variable. The coefficients can be interpreted as indicating that the odds of children living in properties purchased by the smallest class of auction investors exhibiting EBLL are approximately 1.5 times larger than the odds for children living in properties not purchased by an investor at auction. The odds for children living in properties purchased by larger investors are roughly 1.8 times greater than the odds for children living in properties not purchased by an investor at auction. This model also includes a measure of the time in years since the auction acquisition occurred, which accounts for the duration of properties in investor inventories and the effect this may have on property conditions and risk of lead exposure. This variable is negatively associated with EBLL, indicating properties purchased at auction several years prior to testing are actually less likely to be linked to EBLL. This perhaps reflects changing patterns of ownership in intervening years or the protective effect of smaller investors' maintenance practices relative to large investors and merits further investigation.

Models 3 and 4 are identical to Models 1 and 2, respectively, but the sample in these models is restricted to likely renter-occupied homes. In these more conservative models, the effects of each level of the tax auction investor variable are slightly lower, though they all remain positively associated with higher odds of EBLL relative to specimens collected from children living properties not purchased at auction by investors. The only significant demolition variable is the categorical variable of two or more nearby future demolitions, indicating the continued importance of nearby vacant properties.

Table 6: Logistic regression results for elevated blood lead level

	Full sample		Renter occupied	
	(1)	(2)	(3)	(4)
Investor: 1–9		1.490^{***} (0.129)		1.357^{**} (0.131)
Investor: 10–49		1.799^{***} (0.103)		1.642^{***} (0.106)
Investor: 50+		1.764^{***} (0.102)		1.613^{***} (0.105)
Years since auction		0.941^{**} (0.029)		0.938^{**} (0.029)
Home age (years)	1.045^{***} (0.002)	1.046^{***} (0.002)	1.048^{***} (0.002)	1.049^{***} (0.002)
Sex: Male	1.248^{***} (0.039)	1.250^{***} (0.039)	1.289^{***} (0.051)	1.292^{***} (0.051)
SEV	0.988^{***} (0.004)	0.991^{**} (0.004)	0.985^{***} (0.006)	0.987^{**} (0.006)
Nearby demos: 1	1.098 (0.088)	1.088 (0.088)	1.178 (0.109)	1.170 (0.110)
Nearby demos: 2+	1.293^{**} (0.122)	1.302^{**} (0.122)	0.990 (0.174)	1.001 (0.174)
Future demos: 1	1.068 (0.063)	1.061 (0.063)	1.129 (0.080)	1.124 (0.080)
Future demos: 2+	1.292^{***} (0.097)	1.283^{***} (0.097)	1.255^{*} (0.122)	1.252^{*} (0.123)
% below poverty	1.003^{*} (0.002)	1.003^{*} (0.002)	1.001 (0.002)	1.001 (0.002)
Constant	0.001^{***} (0.218)	0.001^{***} (0.220)	0.001^{***} (0.281)	0.001^{***} (0.285)
Age in years FE	Yes	Yes	Yes	Yes
Year of test FE	Yes	Yes	Yes	Yes
Month of test FE	Yes	Yes	Yes	Yes
Zipcode district FE	Yes	Yes	Yes	Yes
Observations	38,203	38,203	20,857	20,857
Log Likelihood	−9,805.153	−9,774.009	−5,693.256	−5,676.259
Akaike Inf. Crit.	19,674.310	19,620.020	11,450.510	11,424.520

*p<0.1; **p<0.05; ***p<0.01

Note: Exponentiated coefficients; standard errors in parentheses

6 Speculation, eviction, and demolition

Toxic structures are produced. The relationships and risk identified in this analysis are situated within a private housing market that is structured through a public process of repossession, disposition, and often publicly funded demolition. In other words, public policies have material consequences that impact low-income and vulnerable populations. This section builds on our previous analysis to examine additional environmental hazards that occur as a result of speculative activity. The houses owned by problem investors and speculators increase the risk for those living in the houses they own while increasing the risks for those that live near these houses when they remain vacant or are demolished due to neglect.

Between 2015 and April 2019, approximately 16 % of publicly funded residential demolitions were of a property owned by a problem investor or speculator in the past decade. We found this by linking City of Detroit demolition records with the Property Praxis dataset.[11] Many of the property owners in the Praxis data are large buyers in the annual auction. Akers and Seymour (2018) detail how speculators and problem investors utilize the mortgage foreclosure and the Wayne County tax foreclosure auction as a pipeline for acquisition. The Wayne County tax foreclosure auction is also used by speculators and landlords to dispose of property effectively placing the cost of demolition, arising from deferred maintenance, on to the public.

Table 7 shows the relationship between eviction filings and our data on children with blood tests, restricted to children likely living in rental properties. Using eviction filing records for 2009–2017 from the 36th District Court, we linked our test data to eviction filing records based on parcel identification numbers.[12] We restrict our analysis to filings occurring within 180 days before or 270 days after specimen collection to reduce the likelihood of capturing evictions related to tax foreclosure auction sales, after which investors may evict existing tenants. This table shows that with each increasing level of the investor category, the rate at which children are likely subject to eviction increases. We find roughly 3 in 10 children living in properties owned by the largest bulk auction buyers, those purchasing 50 or more properties, were served with an eviction filing. In contrast, roughly 2 in 10 children living in properties *not* owned by a tax auction investor were served with a filing. As children are not evenly distributed among residences, we also examined the rate at which distinct residential properties (all single-family homes in our sample) were associated with at least one eviction filing while likely occupied by at least one of the children in our sample. We see similarly increasing rates across each level of our investor category variable. Fully 25% of the children in our sample living in a rental unit owned by the largest auction investors were served with an eviction filing, though the actual rate is likely higher due to the limitations of our data.

The bottom panel of Table 7 presents the same relationships as the top panel, but re-

[11] Property Praxis combines City of Detroit Assessor Data and Wayne County Tax Forelcosure sales.

[12] We retrieved parcel identification numbers for eviction filings by matching addresses with Detroit property assessor records. We were unable to match a large number of eviction filing records due to incorrect street address numbers recorded on filings, thus our findings for the relationship between investor-owned properties and evictions are likely conservative. See Seymour and Akers (2019) for details.

stricted to children with EBLL. It shows that auction investors buying 10 or more properties not only served eviction filings on a large percentage of families with children testing with EBLL, but were more likely to do so than landlords who did not acquire their properties at auction. We must note these tables do not offer definitive evidence that large investors evict families with children while simultaneously creating the conditions leading those same children to likely experience lead poisoning. There are numerous factors that may contribute to children's blood lead levels. But the results of this analysis collectively indicate the problematic nature of speculative property investment, particularly through the annual Wayne County tax foreclosure auction, and the clear association between bulk investor-ownership, evictions, and negative health outcomes for Detroit's low-income Black children—the majority of the city's youth.

Table 7: Relationship between eviction filings and children likely living in rental properties

Investor category	Total eviction filings[a]	Filings per child[b]	Parcels with filings[c]	Total parcels[d]	Parcel filing rate[e]	Children with filings[f]	Total children	Child filing rate[g]
0	3,004	20.7	1,992	10,610	18.8	2,618	14,508	18.0
1–9	277	21.3	189	981	19.3	242	1,302	18.6
10–49	580	27.3	400	1,597	25.0	498	2,126	23.4
50+	895	30.6	573	2,145	26.7	732	2,921	25.1
Restricted to children with EBLL								
0	302	24.7	212	1,049	20.2	240	1,223	19.6
1–9	27	25.7	16	91	17.6	18	105	17.1
10–49	68	33.3	48	176	27.3	51	204	25.0
50+	82	29.8	60	236	25.4	65	275	23.6

[a] Distinct case numbers (filings) linked to properties in which at least one tested child resides
[b] Number of filings divided by children living in properties linked to investor category * 100
[c] Distinct residential parcels (properties) with at least one eviction filing
[d] Distinct residential parcels in which at least one tested child resides
[e] Distinct parcels with filings divided by distinct parcels in which at least one tested child resides * 100
[f] Children living in parcels with at least one filing. Number of children determined by distinct combinations of parcel number, date of birth, and sex
[g] Children living in parcels with at least one filing divided by total children in category * 100

Note: Shows the relationship between eviction filings on properties in which children were living at time of specimen collection. Eviction filings restricted to those filed up to 180 days before or 270 days after specimen collection. Includes eviction filings through end of 2016. Restricted to renter occupied properties.

7 Potential Interventions

For those seeking shelter in low-income housing markets, it is a universe of limited choice filled with toxic structures that threaten the health and well-being of their children. In Detroit, an aging housing stock, high rates of mortgage and tax foreclosure, and the rise of bulk owners and speculators milking properties makes these structures particularly dangerous. This report details the relationship between lead poisoning and the life cycle of low-income housing following the financial crisis. Children living in homes owned by an investor active in the annual tax foreclosure auction in Detroit are 1.8 times more likely to exhibit elevated blood lead levels that public health experts associate with life-long negative impacts. Families with children living in these speculator-owned properties are also more likely to be evicted. Risks increase when publicly funded demolition occurs nearby.

By focusing on this housing life cycle we can identify critical intervention points for public agencies to limit potential lead exposure. These opportunities exist because many of these houses pass through public agencies prior to problem investor and speculator purchase, are operated as rental units falling under a city ordinance directly addressing lead and habitability, or the demolition is funded and overseen by a public agency. The City of Detroit and County of Wayne are positioned to intervene effectively and immediately.

A moratorium on the Wayne County tax foreclosure auction and enforcement of participation rules

As in our previous report, we recommend a moratorium on the Wayne County tax foreclosure auction. The auction serves a primary pipeline for bulk buyers to acquire properties. As this report demonstrates this increases the risk of a child being lead poisoned.

In addition, enforcement of existing auction participation requirements, such as not owing back taxes and code compliance on previous purchases, could serve to limit many of these buyers access to properties.

Enforce rental ordinance and increase tenant protections

The City of Detroit added significant enforcement protections to their rental ordinance in fall 2017. This ordinance requires lead inspections, the reduction and control of lead, and a lead clearance prior to the landlord receiving a certificate of rental registration. This includes fines for non-compliance that start at $500 for a single-family house and that can be assessed daily. This is a significant tool available to the city.

Our findings suggest targeted enforcement of this ordinance on landlords with ten or more single family residential rental units would have the greatest impact in limiting a child's exposure to lead.

In addition, other research shows and anecdotal evidence from Detroit indicate that tenants often face retaliatory eviction for seeking out lead remediation programs on their own or after a positive test in their child. The city's rental ordinance would be significantly improved by extending protections to tenants who actively seek improvements to properties that are not up to code or in violation of the ordinance, particularly its lead clause.

Mitigate demolition risk

In 2017, the City of Detroit convened a task force on demolition safety and health standards. This task force met to address a DHD report that showed an increase in elevated blood lead levels in children living near publicly funded demolition sites. Our analysis finds a similar relationship. The task force made a series of recommendations including outreach, education, and relocation for residents and training, monitoring, and assessment of demolition contractors.

- The implementation of all task force recommendations.
- The creation of a public reporting mechanism on demolition safety and public health.
- The continued monitoring of the relationship between publicly funded demolition and elevated blood level n by DHD to monitor risks and implement harm reduction strategies.

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