Task Force Recommendations for Improving Demolition Safety and Health Standards

Introduction

In January 2017, the Detroit Health Department (DHD) convened a Taskforce on Demolitions and Health ("Taskforce") to develop a set of recommendations for reducing exposures and potential health impacts associated with possible lead dispersion during demolitions. This taskforce brought together eleven (11) representatives from the Detroit Health Department, Detroit Building Authority (DBA), Detroit Buildings Safety Engineering and Environmental Department (BSEED), and the University Of Michigan School of Public Health.

The Taskforce met four (4) times for two hours each on January 18, 23, 31 and February 7, 2017. During these meetings participants:

- Reviewed the Health Department's analysis evaluating the potential relationship between demolition activity and child lead exposure and provided methodological suggestions for strengthening the robustness of its results;
- Reviewed DHD's comparative analysis of existing pre, during, and post demolition protocols used in Detroit, Chicago, Baltimore, and the East Baltimore Development Incorporated (EBDI, which is a 501c3 organization that developed a case study for demolition protocols in partnership with Johns Hopkins University);
- Discussed DHD's set of initial policy recommendations for improving demolition safety and health standards in Detroit; and,
- Collaboratively developed a set of final recommendations for improving resident notification, contractor and resident education, and agency enforcement processes before, during and after demolitions as well as next steps for implementing those recommendations.

This first iteration of a report is a living document, which outlines recommendations and next steps.

Background

The number of children with elevated blood lead levels (EBLLs) in Detroit has decreased by more than 50% since 2009. The most common source of lead exposure in Detroit is dust from lead-based paint in old housing. Ninety-three percent (93%) of housing stock in Detroit was built before 1978, when lead-based paint was ubiquitous. This decline is likely, in part, the consequence of home abatement among affected children, outreach and education services for children and families affected by lead, and the removal of blighted homes via demolition.

However, demolition may also release lead-containing dust into the environment, which may lead to acute (short-term) lead exposure, even while the removal of lead from the environment may reduce exposures to lead in the long run. The demolition protocol used by the Detroit Demolition Program (the "Detroit protocol") borrows best practices from protocols across the nation, and is considered one of the most effective demolition protocols for suppressing fugitive dust – a potential source of lead exposure and elevated blood lead levels (BLLs) in children (EPA, 2014; Royan et al 2016). Use of the Detroit protocol resulted in 35 percent less lead dust, on average, than standard wet-wet demolitions (Royan et al. 2016). Detroit's dust mitigation protocol was developed with the support of leadership from the Health Department, Buildings Safety, Environmental, and Engineering, and the United States, Environmental Protection Agency. Wet-wet demolitions are demolitions where both the structure and the debris are saturated with water to reduce fugitive dust. Generally, the structure is wetted before and during demolition, while the debris is wetted during transport; however, exact specifications can differ depending on contractor protocols and the building codes of the city where the demolition is occurring.

Nevertheless, a recent analysis by the Detroit Health Department reveals that demolitions occurring within 400 feet of childhood residence 15 to 45 days prior to a blood lead test may elevate blood lead levels. This analysis is being replicated by 3rd party analysis to address the potential for stronger or weaker associations between demolitions and elevated blood lead. Therefore, additional measures are warranted to reduce or mitigate the potential child lead exposures in the current demolition process. This analysis also suggests that risk of increased BLLs is most significant for demolitions occurring during the months of May through September and for children living very close (within 200 feet) of the demolition. Effects were not significant for demolitions occurring during the months of October through April.

This report outlines recommendations for how the Detroit Building Authority (DBA) and City partners could mitigate potential lead release and exposure. Given DBA's success at reducing fugitive dust during and after demolition, these recommendations include improvements to notification and enforcement processes that can lower risks of exposure. Overall enforcement recommendations are provided, as well as recommendations pertaining to each stage of the demolition process – pre-demolition, during demolition, and post-demolition. The recommendations are meant to provide general guidance, and to spawn working groups that will operationalize them and fill in specific details. Further, this document is meant to be a 'living' document, with potential updates from subsequent working groups and task forces.

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Recommendations

This first iteration of recommendations outlined below were identified by the taskforce as further public health protections that should be incorporated into the Detroit demolition protocols. Recommendations are organized by the three stages of the demolition process—pre-demolition, during demolition, and post-demolition—and can be broadly characterized as improvements in notification, education, and enforcement. As a next step, taskforce members should work in small groups and with contractors to develop detailed operational plans for each recommendation as well as a timeline for implementation.

A. Pre-Demolition Recommendations

The taskforce envisions a comprehensive alert and education system which would feature door hangers providing information for opt-in text alerts; visits by lead advocates for families with children under the age of six; comprehensive education and provision of demolition care packages; and provision of travel, recreational, or hotel vouchers. In addition, efforts to fortify and improve demolition protocol availability, metrics, and training are included.

A1. At least two weeks prior to demolition, contractors should provide door hangers to all resident homes and community organizations located within 400 feet (or within a radius of 8 houses) of the demolition site.

Currently, Detroit demolition protocols require contractors to provide door hangers to residents living in the eight houses closest to a demolition site at least three days prior to a demolition. However, a study of lead dust fall at scattered demolition sites in Chicago showed that elevated levels of lead dust can extend 400 ft. (or within a radius of approximately 8 houses) from the demolition site, placing non-adjacent residents at risk for increased lead exposure (Jacobs et al., 2013). These findings were consistent with the Health Department analysis. In order to strengthen public health protections, the Detroit protocol should require contractors to provide door hangers to households within 400 feet (or within a radius of 8 houses) of a site two weeks in advance to notify them of an upcoming demolition. Borrowing from best practices outlined in the Chicago, Baltimore, and East Baltimore Development Incorporated protocols, the door hanger should include the proposed start date of the demolition, the address of the demolition, contact information for the contractor, a link to a website and phone number families can call to receive further information about the demolition, information about an opt-in text messaging program for receiving alerts (described below), and tips for mitigating the spread of lead-containing dust *(Baltimore Building, Fire, and Related Code 105.9.1; EBDI 2010; Chicago Municipal Code 13-124-105).*

A2. Create an opt-in text message program to allow residents and other community organizations to sign up for demolition updates and request a home visit from the DHD Lead Advocate Team.

Text messaging has been shown to be an effective mechanism for health-related interventions aimed at underserved populations (Head et al., 2013; Free et al. 2013; Militello et al. 2016). This is due in part to the fact that lower-income populations are very likely to text and to rely on smartphones as their

primary source of internet access (Smith, 2015; Smith, 2011). Detroit could create a text-messaging program – similar to Chicago's ChiText and Notify Chicago! Initiatives – that allows residents to sign up for text alerts about upcoming demolitions on their street. The text program could also enable families with children six years of age and younger to request a demolition care package (e.g., containing lead cleaning and mitigation tools), an in-person visit from a lead advocate, and other information to help prepare for a demolition. The program should be run as a collaboration between DBA and the Health Department—wherein DHD uses DBA contractor data to send texts through a text-messaging system. DBA and DHD should work together to effectively design the text-messaging program, but the program should aim to notify families via text 36 hours before a demolition is to occur. A backup notification system and operational plan should be developed for notifying families In the event of an emergency demolition or other extenuating circumstances.

Community organizations (such as churches, business and other community groups) located within or near the demolition zone should also have the ability to sign up for the text messaging program to improve the efficacy of the notifications, particularly for residents who do not live in adjacent properties, but who may still come into contact with the demolition zone. With prior notification, community organizations can help coordinate services to support residents living in the area.

A3. Two weeks prior to a demolition a lead advocate should visit and provide demolition care packages to community organizations and homes with children under six years of age and pregnant mothers living within 400 feet of the demolition site (or within a radius of 8 houses).
In addition to providing door hangers to families two weeks prior to a demolition, the Detroit protocol should require that up to two weeks prior to a demolition, families with children under six years of age living near an upcoming demolition who opt in via text message and/or are identified via birth certificate data receive a home visit from DHD lead advocates and a demolition care package.

Lead education for families with children under the age of six is vitally important to reducing the risk of families and children unknowingly putting themselves in harm's way. Studies have shown that residents leave windows open, leave pets outside, and even gather to watch demolitions (Farafel et al., 2003; AECF, 2011). Without education about the health impacts of demolitions, residents may unknowingly place themselves—and their children—at risk. Modeled from the EBDI case study protocol, where outreach facilitators were hired to distribute educational materials and conduct door-to door education at least two weeks before demolition began (AECF, 2011), the Detroit Health Department's Lead Advocate Team would provide door-to-door education to families living within 400 feet (or within a radius of 8 houses) of a demolition site on how to mitigate the health impacts of lead-containing dust as well as distribute housing or travel vouchers requested by the family. To schedule a home visit and receive lead education services, families could either place a request through the DET-DEMO text message notification program or by calling the Health Department. Lead advocates would also visit schools, churches and other community organizations in areas with upcoming demolitions to schedule visits with interested residents.

Lead advocates will be trained regarding how best to counsel families and to provide a balanced message about the benefits and potential harms of demolition, but lead education messaging should include:

- Pre-Demo Education:
    - Providing information about how and where families can access fresh fruits and vegetables within the City.
    - Encouraging eligible families to enroll in WIC services to improve children's access to fresh fruits and vegetables, which can help mitigate the negative physiological effects of lead.
    - Educating families about demolition safety procedures.
    - Educating families about the consequences of lead exposure.
- Day of Demo Education:
    - Advising the departure from a house on the day of the demo and distributing "activity vouchers" (for a City recreation center activity, day camp, neighborhood ice cream day, etc.) to residents with children six years old and younger to encourage these families to leave the premises during active demolition.
    - Closing windows during a demolition--although messaging should address appropriate practices for families living in homes without air conditioning during the hot summer months.
    - Encouraging that people remain off the perimeter street during a demolition.
- Post-Demo Education:
    - Advising that children should not play in the dirt.
    - Advising that parents should not let children or pets wander into demolition sites.
    - Advising proper clean up procedures, such as techniques for wiping down a house or window sills.

The Detroit Building Authority (DBA) and Detroit Health Department (DHD) can partner to design the contents of the demolition care package to be brought by the lead advocates. They should target families with children under six years of age, develop an effective procedure for distributing care packages, and schedule home visits with the Detroit Health Department lead advocate team. For example, to target families with children under six, DHD could receive the addresses of all upcoming demolitions from DBA and then use birth certificate data to identify which homes within 400 feet (or within a radius of 8 houses) of the demolition site may have children under six.

The Demolition care packages could include lead cleaning supplies for the home, hand wipes, a voucher for a fan, a microfiber cloth for cleaning windowsills (possibly printed with the information and phone number for text message notification), information about the text message notification program, an outline of the requirements contractors must follow during the demolition, a list of tips for how to protect children during the demolition, information about how to schedule a home visit and lead education services from a Detroit Health Department lead advocate, and information about how to request a housing or transportation voucher for families with children under the age of six (described below).

A4. Provide transportation, housing, and activity vouchers to families living within 400 feet (or within a radius of 8 houses) of a demolition site and with children under six years of age to allow them to relocate during demolition

Parents should also be able to request transportation or hotel vouchers if they wish to relocate during demolition. The demolition care packages would contain information about how a family could request these vouchers and the voucher could be distributed either during the home visit with a Lead Advocate or by mail. It should be made clear that relocation is voluntary and solely left to the discretion of the parents—even if vouchers are distributed without prior request and/or as part of the demolition care packages. As an alternative, demolition efforts could be coordinated with the Parks and Recreation department to set-up community activities for families within neighborhoods with high-levels of demolition so that they may remove themselves from the area.

A5. Improve public visibility of the demolition checklist, protocols, and lead safe training materials on the DBA website

Currently, the demolition protocol (titled "Scope of Services") is located in the "Open RFPs and RFQs" section of the DBA website, on the DHD website, as well BSEED's website. It should be moved to a more visible and prominent location to increase access and visibility.

A6. Provide Lead Safe training to Contractors

DHD should develop a Lead Safe Training for demolition contractors. This training would provide a standard knowledge base for contractors, help to ensure that they understand the dangers of lead dust, and, in doing so, provide the rationale for the increased focus on dust suppression. The focus of these trainings will be identifying sources and consequences of lead for children, but DHD will engage with contractors before and after each class to target the class to their needs.

To clarify how contractors are interpreting the current guidelines, evaluate contractors' baseline knowledge, and determine where further support and training is needed, observations—particularly of active demolitions—and interviews with contractors should be conducted. Interviews should focus on learning which parts of the current protocol contractors find most burdensome and identifying potential solutions. These interviews should also evaluate the lead safety culture among current contractors, including questions such as:

- How does lead exposure occur to children?
- What issues might be increasing the risk of child lead exposure?
- How are contractors finding these issues?
- Do contractors understand why they are looking for particular issues or problems, and if they find problems, what do they do as a result to fix them?
- Can contractors describe a recent lead safety problem they encountered? How did employees respond, and what preventive measures are in place as a result?

B. During Demolition Recommendations

B1. Develop a mechanism for inspecting all demolition sites to develop a baseline for contractor compliance and performance.

The Blight Task Force Report from 2014, reported that the City of Detroit, the Detroit Land Bank Authority (DLBA), and the Detroit Building Authority (DBA) recognized the lack of regulation around lead and how it is handled. At the same time they recognize the importance of creating a safe and healthy environment for Detroit residents. To that end, in April 2014 this team, along with the Michigan Department of Environmental Quality and Region 5 Environmental Protection Agency designed an approach that included, among other things, the use of field liaisons and use of “wet/wet” demolition removal techniques.

In July 2015 to November 2015, the DBA provided complete access to demolition sites and work schedules to an independent research team from the University of Michigan School of Public Health audit and study the demolition work in the field. In February 2016, the preliminary results of this study found that "the Detroit Protocol" resulted in "lower geometric mean levels of lead dust than the wet-wet methods recently used in Chicago."

The study called out that "the important strength of this work is the access that researchers [were] given to demolition sites, allowing us to capture the whole demolition event and also collect samples close to the work area."

Currently 60-70% of demolitions are visited by Field Liaisons. However to gain even greater adherence to the Detroit Protocol, for a period of 1-3 months, independent 3rd party inspectors should seek to observe 90-100% of all demolitions, starting before the contractor begins work on site. The inspectors should confirm that contractors are in compliance with the DBA pre-demolition checklist. After the 1 -3 month period of targeting 90-100% inspections is over, contractors in compliance with the checklist, will drop to a 20-30% targeted inspections rate, while contractors deemed not in compliance with the checklist will remain at the targeted 90-100% inspection level and may be required to pay for the heightened inspections. These inspectors will be in place solely to monitor the work and will report any violations to DBA Field Liaisons. If contractors who have been dropped to the 20-30% targeted inspection rate are found to be in violation of their requirements, their targeted inspection rate will be increased back to the 90-100% targeted inspection level.

B2. Develop a demolition checklist for contractors and independent inspectors that describes pre-, during and post-demolition activities

DBA is currently developing a paper checklist for contractors of critical equipment that should be on site and procedures that should be followed and replicated across sites. This checklist should be published on the DBA website and residents should be encouraged to report non-compliant contractors to DBA.

Critical procedures to follow should include:

- Prescriptive standards and procedures for pre-wetting a house;
- Prescriptive standards for open hole fencing; and,
- Prescriptive standards for wetting streets and sidewalks post demolition.

B3. Conduct ongoing air monitoring at demolition sites

The current demolition protocol requires contractors to perform "daily air sampling and analysis for concentrations of lead dust in accordance with…MIOSHA." Sampling is only required during demolition; contractors can discontinue sampling during load out, per their discretion. Permissible exposure limits are based on OSHA standards for adult workers, rather than EPA standards for EBLL in children. To date, monitoring has been conducted only for asbestos. Therefore, it is necessary to expand air monitoring to include sampling conducted specifically to monitor potential exposures of lead and dust generated by demolition and load out. Possible options for monitoring include:

- Enlist third party contractors or field liaisons or independent auditors to conduct air monitoring;
- Train contractors to measure the concentration of dust in the air, and require records of such measurements during demolition and load out; and,
- Provide contractors with air monitoring equipment, which can measure the concentration of dust in the air; equipment used for asbestos monitoring could also be configured for lead monitoring.

B4. Conduct ongoing ambient air monitoring for lead at representative population sites

Ambient air monitoring is conducted by the Michigan Department of Environmental Quality and includes lead monitoring at several Detroit area sites (Allen Park, Salinas School in Dearborn, Fort Street, and Mt. St. Herman Baptist Church), however, these are mostly industrial sites and not optimal locations for demolition monitoring. Instead, population weighted monitoring for lead is desired. An additional permanent monitor should be installed on the East side of Detroit. Transportable monitors should be installed at selected demonstration sites to monitor pre, during, and post- demolition. Schools could also be a good location for placing additional air monitors.

B5. Implement wind advisories for demolitions

High winds can increase the spread of fugitive lead dust emissions (Farafel et al., 2005). Instituting wind advisories for demolitions—including "cutoff" wind speeds that require contractors to pause or delay demolition until winds die down—would mitigate these problems. The current protocol specifies a wind speed of 25 mph, but two part wind advisory is suggested where demolitions and load outs would not take place on high wind periods (above 15 mph) or if visible dust is seen or anticipated to migrate off-site.

C. Post-Demolition Recommendations

C1. Include clear signage on properties where demolitions are occurring to keep children out of demolition sites

Clear signage should be installed near the sidewalk on properties where a demolition is occurring to encourage people to stay on the sidewalk.

C2. Standardize street and sidewalk wetting procedures

Levels of exterior lead dust declines post-demolition because of the combination of street and sidewalk wetting that occurs after knockdown (Jacobs et al., 2008). The EPA also recommends street wetting as an important lead abatement strategy after demolitions (EPA, undated). Detroit contractors are currently required to wet the sidewalks at two points: after demolition is completed and after the site is finished (DBA, 2016). Post-demolition street and sidewalk wetting should be standardized with prescriptive criteria, and consist of hosing off the streets and sidewalks.

C3.Consider offering protection to neighboring homes in adjacent properties

To further mitigate the risks to children living in adjacent properties, DBA could consider contractor protocols and protections for adjacent homes (such as wetting or other procedures) following the demolition. Prior to implementing protections, the relevant legal, operational, and safety barriers should be explored and remedied.

C4. Develop a public dashboard of critical health and performance metrics for lead demolition contractors based on lead safety

Currently, the DBA does not have performance metrics for contractors beyond the number of violations and the number of demolitions completed. Instituting additional metrics based on lead safety and incentivizing good performance by highlighting those metrics on a public dashboard could both improve health outcomes and increase the effectiveness of current enforcement measures. These metrics could be integrated into DBA's current suspension and debarment procedures to ensure adequate enforcement.

C5. Encourage the Michigan Department of Environmental Quality (MDEQ) and the Michigan Department of Technology, Management, and Budget (DTMB) to improve bureaucratic processes for DBA and demolition contractors

The Detroit Health Department should work with state agencies to make processes more efficient and help to focus the system on mitigating the public health consequences of demolitions.

C6. Include a Health Department representative on the DBA Demolitions Appeals Board

C7. The Demolitions and Health taskforce should be continued on a regular basis to provide timely updates to the epidemiological study, review monitored and collected data, analyze trends and performance metrics, continuously improve demolition protocols and conduct further research.

Abstract
Blight demolition has clear public health benefits, including improving mental health, reducing crime, and improving socioeconomic circumstances. Detroit's blight removal program is the world's largest and follows the strictest published protocols to mitigate lead release. However, demolition may still have some potentially negative consequences, such as the release of lead into the environment. Nearly 9% of children tested were found to have elevated blood lead in Detroit in 2015, although that number has decreased from 19% in 2009. We sought to understand the influence of demolition activity on lead exposure in children under 6 between 2014 and 2016 in Detroit. We conducted a retrospective analysis of 50,094 unique children to understand the influence of demolition activity on the likelihood of a positive test adjusting for individual and neighborhood factors. We found that living within 400 feet of a demolition increased the odds of elevation 20%. The odds increased 38% if there were two or more demolitions. Significance of this relationship was limited to summer months. Sensitivity analyses showed a dose-response relation between proximity in time and space to demolition and risk of elevated blood lead. On a population level, about 2.4% of cases of elevated blood lead levels in Detroit may be attributable to demolitions. Our findings suggest that further protections are necessary to mitigate the potential harm for high-volume demolition.

Introduction

The charge of public health is to produce the maximal health benefit for the greatest number, equitably across society. In that respect, any potentially positive health consequences of a given project or policy must be weighed against potential hazards.

Childhood lead exposure is a serious challenge in Detroit where 7.5% of children under 6 and 9% of children aged one and two years old were exposed in 2015.[1] This is largely due to exposure in homes laden with lead-based paints, which were not outlawed until 1978. Over 90% of Detroit homes were built before 1978. Nevertheless, childhood lead exposure declined over 50% between 2009 and 2015.[2] While the causes of this decline are not known, they are likely the byproduct of improved knowledge about the causes of lead exposure among parents, abatement of homes where children are exposed, and the removal of blighted homes.

In 2014, the City's Blight reduction task force identified over 40,000 blighted homes, with an additional 39,000 at risk for becoming blighted. Blighted homes present a substantial public health

[1] Maqsood J, Stanbury M, Miller R. 2015 Data Report on Childhood Lead Testing and Elevated Blood Lead Levels: Michigan. Michigan Department of Health and Human Services. February 2017.
[2] El-Sayed A, Hill A, Haroon H. Lead Report 2016. Detroit Health Department. April 2016.

burden. Directly, they are a nidus for criminal activity—including violent crime and drug abuse—stray dogs, and injuries for children who wander onto the premises. Indirectly, they depress surrounding housing prices, reinforcing the cycle of poverty that drives poor health in urban areas like Detroit.

The City of Detroit is demolishing blighted homes at an unprecedented rate. Between May 2014 and December 2016, over 10,000 structures were demolished. Given the potential for lead release into the environment during demolition, [3,4] and the potential for elevated blood lead levels among children exposed to demolitions,[5] there is concern about how best to mitigate the potentially hazardous consequences of demolition when it occurs at such a rapid pace. Officials at the Detroit Building Authority have innovated in their approach to lead suppression in response, using a 'wet-wet-wet' protocol, which involves flooding the home prior to demolition, wetting the home throughout demolition, and using a water canon at the point of the loading of debris.

Nevertheless, considering the unprecedented scale of demolitions in Detroit, the potentiality of a relation between demolition activity and lead exposure remains. Three years into the demolition program, the Detroit Health Department assessed the relation between demolition activity and the risk of childhood lead exposure in children under 6 years old.

Methods

A retrospective cohort study examined the relationship between exposure to home demolitions and subsequent elevated blood lead level (EBLL) by combining lead test data from the Michigan Department of Health and Human Services (MDHHS) with publically available data. Using data from

[3] Farfel MI, Orlava AO, Lees PS, Rohde C, Ashley PJ, Chisolm JJ. A study of urban housing demolitions as sources of lead in ambient dust: demolition practices and exterior dust fall. Environ Health Perspect. 2003;111(9):1228-34.
[4] Jacobs DE, Cali S, Welch A, et al. Lead and other heavy metals in dust fall from single-family housing demolition. Public Health Rep. 2013;128(6):454-62.
[5] Rabito FA, Iqbal S, Shorter CF, et al. The association between demolition activity and children's blood lead levels. Environ Res. 2007;103(3):345-51.

Detroit's Open Data Portal,[6] we established a count of home demolitions conducted within a 400-foot radius of the address of a child who received a blood lead test between 2014 and 2016, and no more than 45 days before the blood lead test occurred. The 400-foot radius accounts for the estimated dispersion zone for lead dust from a demolition employing dust suppression techniques (e.g. wetting),[7] and the 45-day period accounts for the half-life of lead in the blood.[8] The demolition variable was first categorized into two levels of exposure: one demolition and two or more demolitions. To retain power in sub-analyses, we also created a dichotomous exposure variable (any demolitions/no demolitions).

EBLL status was determined using Michigan Department of Health and Human Services data from all reported blood lead tests for children six years old and younger in Detroit, tested between January 1, 2014 and December 31, 2016. The original dataset included 74,309 geocoded observations representing 50,094 unique Detroit residents from birth to age six. For children who received multiple tests in the past three years, only the most recent test was used for analysis. The children were grouped into three categories based on lead test results: low blood lead levels (1 µg/dL – 4 µg/dL), moderately elevated blood lead levels (5 µg/dL – 10 µg/dL), and severely elevated blood lead levels (10 µg/dL or higher).

Proportional odds ordered logistic regression models were used to examine the relationship between the intensity of demolition activity and subsequent blood lead levels in nearby children. Potential models were compared to minimize confounding and maximize fit, power, relevance and interpretability. The final model adjusts for potential confounding by age, sex, proximity to other vacant structures, season, and neighborhood social vulnerability. Age at the time of lead testing, calculated using the child's birthday and the test date, was coded into three categories to account for the fact that

[6] City of Detroit. Detroit Open Data Portal. Accessed 02/02/2017. https://data.detroitmi.gov/.
[7] Rabinowitz MB, Wetherill GW, Kopple JD. Kinetic analysis of lead metabolism in healthy humans. J Clin Invest. 1976;58(2):260-70.
[8] Jacobs DE, Cali S, Welch A, et al. Lead and other heavy metals in dust fall from single-family housing demolition. Public Health Rep. 2013;128(6):454-62.

the risk to EBL by age is not linear, but rather changes over development stages, such as crawling beginning and ending. A binary variable for child's sex, from MDHHS lead test data, was also included. The model attempts to account for the likelihood that children living near demolitions also live near other vacant structures that contribute to EBL risk. We also included a binary control variable for season (May to September versus October to April), because both demolition density and blood lead levels are higher in the summer. Finally, we attempted to control for neighborhood socioeconomic status by including the CDC's Social Vulnerability Index (SVI), which is produced using 15 census variables capturing various socioeconomic indicators. All models were fit using the R package "ordinal."[9]

Sub-analyses were performed to assess dose-response by proximity in space and time, and varying effects by year and season. We conducted two sensitivity analyses to assess whether the relationship between exposure to demolitions and EBLL follows an anticipated dose-response pattern, strengthening at closer distance and in shorter time frames. To explore potential differences by length of time between exposure to demolitions and subsequent blood lead test, we created a set of models that specified whether or not any demolitions occurred in the following time periods: during the 15-day pre-test period, between 15 and 30 days pre-test, between 30 and 45 days pre-test, and between 45 and 60 days pre-test. The use of time intervals allow us to isolate the influence of additional demolitions further in time from the child's lead test. A similar approach was used for distance, starting with a 200-foot buffer and adding increasingly distant rings in 200-foot intervals to a maximum distance of 1000 feet from the child's residence.

Using the original 400-foot buffer and 45-day time frame, we also considered attributable risk proportions among exposed children and among all children included in the analysis. We then explored two potential interactive factors: year and season. Interaction by year was anticipated due to the

[9] Christensen, R. H. B. (2015). ordinal - Regression Models for Ordinal Data. R package version 2015.6-28. http://www.cran.r-project.org/package=ordinal/

increased rigor of dust suppression protocols introduced in 2015. To assess potential interaction by year, we compared interaction models to models without interaction terms, using likelihood ratio tests to assess whether interaction terms improved model fit. After testing for interaction, we re-ran the regression stratified by year. We also examined whether the relationship between exposure to demolitions and EBLL differs in the summer, when children are home from school and likely to play outside. Demolition activity and blood lead levels also tend to be greater in the summer. We again fit and compared interaction models to models without interaction terms, and then fit models stratified by season.

Results

Descriptive analyses reveal that about half of children tested for lead in Detroit are tested during the months between May and September, and that children under one year old and older than four years old are less likely to be tested than children between ages one and four (Table 1). The children included in this study live in disproportionately vulnerable neighborhoods as compared to their national peers, with 83.2% residing in a census tract that is deemed by the CDC to be in the most vulnerable quartile (Table 1). In addition to living in vulnerable neighborhoods, the children in our sample are highly exposed to vacant structures that can serve as sources of lead exposure and other dangers. About a third of the children in our sample live within 200 feet of five or more vacant structures (Figure 1).

Nearly 6% of children in our sample were exposed to at least one demolition within 400 feet of their residence in the 45 days before they received a blood lead test, as compared to about 2% within 200 feet and about 20% within 1,000 feet (Table 2). About 7% of the children in our sample have blood lead levels at or above 5 μg/dL (Table 3).

Table 4 describes five increasingly adjusted ordinal logistic regression models quantifying the relationship between exposure to demolitions within 400 feet of a child's home and the results of a blood lead test taken within the subsequent 45 days. The final model, adjusted for age, sex, neighborhood social vulnerability, season, and vacancy, suggests that a child exposed to one demolition within 400 feet of his or her house, as compared to an unexposed child, has 20% higher odds of moving from low blood lead to moderately elevated blood lead (95% CI for OR: 1.03 – 1.40), or from moderate EBL to severe EBL. A child exposed to two or more demolitions appears to have 38% higher odds of moving from low blood lead levels to moderate EBL or from moderate EBL to severe EBL, as compared to an unexposed child (95% CI for OR: 1.07 – 1.74). This discrepancy is evidenced in the higher relative prevalence of EBL among children exposed to demolitions as compared to unexposed children (Table 5). The discrepancy between exposed and unexposed children accounts for a population attributable risk fraction of 2.39% (95% CI 1.47% - 3.30%).

The results of the sensitivity analyses (Tables 6 and 7) suggest a dose-response relationship between demolitions and EBL, with strength increasing with proximity in both space and time. After accounting for the first 15 days between demolition and test, point estimates remain elevated but insignificant for two subsequent 15-day time intervals. After 45 days, there is no longer an association between demolition activity and EBLL. Similarly, children exposed to demolitions in a 200-foot buffer around their residence, and within an additional 200-foot ring extending out to 400 feet have higher odds of EBL as compared to unexposed children. A relationship between demolition exposure and odds of EBL is not evident for children who live more than 400 feet from a demolition site.

Interaction analyses (Tables 8 and 9) reveal significant interaction by season and by year. During the months between May and September, the odds ratio for EBL among children exposed to one demolition versus unexposed children increases from 1.20 (95% CI: 1.03 – 1.40) in the all-years model to 1.35 (95% CI: 1.13 – 1.61) in the summer-only model. The odd ratio for moving into a more severe EBL

category when exposed to two or more demolitions, compared to no demolitions, increases in the summer from the all-year estimate of 1.38 (95% CI: 1.07 – 1.74) to the summer-only estimate of 1.59 (95% CI: 1.20 – 2.07). Between October and April, our ordinal logistic regression model detects no association.

Results of ordinal logistic regression models stratified by year (Table 9) suggest an abatement of the association in 2015, with an odds ratio of 1.05 (95% CI 0.74 – 1.44) for exposure to one demolition as compared to none. The odds of EBL following exposure to a single demolition appears lower in 2016 (OR 1.19, 95% CI: 0.97 – 1.45) as compared to 2014 (OR 1.49, 95% CI 1.05 – 2.07), but exposure to multiple demolitions appears to increase odds of EBL more in 2016 than in any of the previous years (OR 1.73, 95% CI: 1.23 – 2.38).

Discussion

Our retrospective observational analysis of 50,094 unique observations over 3 years of EBL tests in Detroit demonstrated a significant association between demolition activity within 400 feet of a child's home and likelihood of elevated blood lead in a subsequent blood lead test. Our analysis suggests a dose-response relation, demonstrating that the risk of elevations decrease with distance in time and space. In addition, our findings showed no association during winter months. The population attributable risk fraction reveals that less than 3% of all cases of EBL in Detroit are attributable to demolitions. Taken together, our findings suggest that demolition activity may increase risk of EBL during the summer months when children are most likely to be exposed to environmental lead release from demolition activity. However, demolition activity does not appear to be a major driver of EBL among children in Detroit on a population level.

Our findings are subject to a number of critical limitations. Our findings are retrospective and observational. While we adjusted for several important confounders and conducted sensitivity analyses

stratified across third variables, there remains the potential for confounding given that children most likely to be exposed to demolition activity are also most likely to be exposed to lead in their homes and neighborhoods. Further, we were unable to assess the mechanism of action connecting demolition activity and EBL. While it is clear that demolition activity can release lead into the environment, the form in which lead is most likely to reach children is not.

Our findings suggest that additional protections are needed to limit the potential health consequences of demolition activity. A task force to identify opportunities for further improvement and implementation is recommended. Further, more research is needed to understand the mechanisms by which lead may be released and children may be exposed. This research should be prospective, identifying lead release into air, water, and soil resulting from demolition activity. Finally, these findings must be balanced against the clear public health benefits of demolition activities. While taking precautions to limit and mitigate the potential negative consequences of demolition activities is necessary and prudent, this must be weighed against the long-term benefits of blight demolition for mental health, crime, and lead elimination. Toward that end, more research is also needed to understand the long-term health consequences of demolition activity in Detroit.

Table 1. Descriptive statistics from Detroit children 6 years and younger who received a blood test for lead between 2014 and 2016 (n=50,094)

Child-Level Measurement	Percent of children (n)
Age at last birthday	
Less than 1 year old	6.5% (3232)
1 year old	20.9% (10493)
2 years old	15.5% (7745)
3 years old	15.5% (7758)
4 years old	22.2% (10601)
5 years old	12.5% (6242)
6 years old	8.0% (4023)
Sex	
Female	48.8% (24457)
Male	50.7% (25404)
Unknown or Other	0.5% (233)
Season of Test	
May – September	49.2% (24631)
All Other Months	50.8% (25463)
Census Tract Social Vulnerability Index	
0 – 25	0.2% (120)
25 – 50	2.8% (1379)
50 – 75	13.8% (6914)
75 – 100	83.2% (41586)

Demo

Figure 1. Vacant houses within 200ft of residence among children 6 years and younger tested for lead in Detroit, 2014-2016

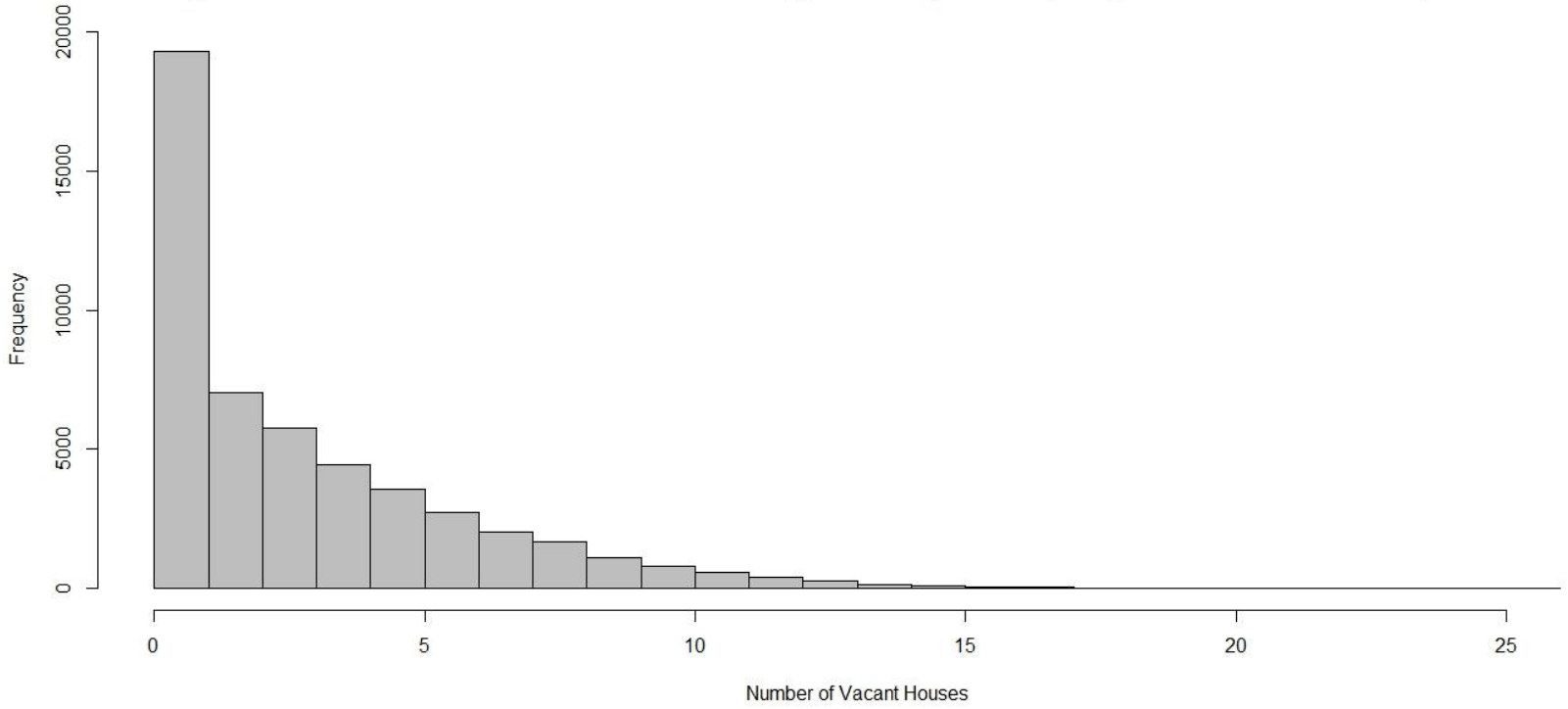

Table 2. Intensity of demolitions within 200ft or 400ft of a child's residence and within 45 days of that child receiving a blood lead test, among Detroit children six years old and younger who received a blood lead test between 2014 and 2016 (n=50,094)

Number of demolitions, 45 days before lead test	**400 feet from residence**	**200 feet from residence**	**1,000 feet from residence**
	Percent of children (n)		
0 Demolitions	94.3% (47227)	98.1% (49167)	79.6% (39874)
1 Demolition	4.3% (2164)	1.6% (799)	11.5% (5749)
2 or More Demolitions	1.4% (703)	0.3% (128)	8.9% (4471)
Range of demolition exposure (count in buffer zone, 45 days pre-test)	0 – 14	0 – 5	0 – 62

Table 3. Distribution and summary statistics of blood lead level (BLL) results from children six years old and younger in Detroit, 2014-2016 (n=50,094)

BLL Range	Percent of children (n)
0 – 5 µg/dL	93.2% (46664)
5 – 10 µg/dL	5.6% (2812)
10 µg/dL or higher	1.2% (618)
Blood Lead Levels (BLL) Summary Statistics	**Amount of lead in micrograms per deciliter**
Range of BLL	1 µg/dL – 47 µg/dL
Geometric Mean BLL	1.72 µg/dL

Table 4. Unadjusted and increasingly adjusted ordered logistic regression models examining the relationship between blood lead levels (low, moderate, and severe) and exposure to demolitions (none, one, two or more) within a 400 foot radius in the 45 days before testing, among all tested Detroit children 6 years old and younger, 2014-2016

	Odds Ratios(95% CI) for Categorical Blood Lead Level (Low, Moderate, Severe)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Demolition Activity					
1 Demolition	1.40***	1.42***	1.37***	1.31***	1.20**
	(1.20, 1.62)	(1.21, 1.64)	(1.17, 1.58)	(1.12, 1.52)	(1.03, 1.40)
2 or More Demolitions	1.71***	1.76***	1.70***	1.61***	1.38***
	(1.34, 2.16)	(1.37, 2.22)	(1.32, 2.14)	(1.26, 2.03)	(1.07, 1.74)
Covariates					
Age 1-2		2.71***	2.70***	2.69***	2.69***
		(2.23, 3.32)	(2.22, 3.31)	(2.22, 3.30)	(2.22, 3.30)
Age 3-6		1.87***	1.85***	1.81***	1.79***
		(1.55, 2.30)	(1.53, 2.27)	(1.50, 2.22)	(1.47, 2.19)
Male Sex		1.21***	1.21***	1.21***	1.22***
		(1.13, 1.30)	(1.13, 1.30)	(1.13, 1.30)	(1.14, 1.31)
Census Tract SVI			1.02***	1.02***	1.01***
			(1.01, 1.02)	(1.01, 1.02)	(1.01, 1.02)
May to September				1.30***	1.31***
				(1.21, 1.39)	(1.22, 1.40)
Vacancy within 200ft					1.07***
					(1.06, 1.08)
N	50094	49861	49766	49766	49766
Log Likelihood	-14115.84	-13954.98	-13898.97	-13872.34	-13792.06

***p < .01; **p < .05; *p < .1

Table 5. Prevalence and attributable fraction among the exposed and among the population of children included in analysis for elevated blood lead levels (at or above 5 µg/dL) by exposure to demolitions within 400ft of residence in the 45 days before receiving a blood lead test among children 6 years old and younger who received a blood lead test in Detroit between 2014 and 2016 (n=50,094)

Prevalence of EBLL	**Per 100 Children**
Exposed	9.56
Unexposed	6.69
All	6.86
Attributable Fraction	**Per 100 Children (95% CI)**
Exposed	29.97 (21.23, 37.73)
Population	2.39 (1.47, 3.30)

Table 6. Adjusted ordinal logistic regression models considering the potential dose-response relationship between exposure to nearby demolition activity (400ft radius) and blood lead levels (low, moderate, severe) within mutually exclusive 15-day time intervals from 0 to 60 days

	Odds Ratios(95% CI) for Categorical Blood Lead Level (Low, Moderate, Severe)			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Demolitions				
Any Demolitions 15 Days Pre-Test	1.34*** (1.08, 1.64)	1.35*** (1.09, 1.65)	1.35*** (1.09, 1.66)	1.35*** (1.09, 1.66)
Any Demolitions 15-30 Days Pre-Test		1.18 (0.94, 1.47)	1.18 (0.94, 1.47)	1.18 (0.94, 1.47)
Any Demolitions 30-45 Days Pre-Test			1.19 (0.94, 1.49)	1.19 (0.94, 1.49)
Any Demolitions 45-60 Days Pre-Test				1.00 (0.77, 1.27)
Covariates				
Age 1 – 2 Years	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.31)	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.30)
Age 3 – 6 Years	1.79*** (1.48, 2.20)	1.79*** (1.48, 2.20)	1.79*** (1.48, 2.20)	1.79*** (1.48, 2.20)
Male Sex	1.22*** (1.13, 1.30)	1.22*** (1.13, 1.31)	1.22*** (1.13, 1.31)	1.22*** (1.13, 1.31)
Census Tract SVI	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)
May-September	1.31*** (1.23, 1.41)	1.31*** (1.22, 1.41)	1.31*** (1.22, 1.40)	1.31*** (1.22, 1.40)
Vacancy in 200ft Radius	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)
N	49766	49766	49766	49766
Log Likelihood	-13794.10	-13793.11	-13792.03	-13792.03

***p < .01; **p < .05; *p < .1

Table 7. Adjusted ordinal logistic regression models considering the potential dose-response relationship between exposure to nearby demolition activity and blood lead levels (low, moderate, severe) within 45 days, with dichotomous exposure in 200ft concentric rings from 0ft to 1000ft in Detroit, 2014-2016

	Odds Ratios(95% CI) for Categorical Blood Lead Level (Low, Moderate, Severe)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Demolitions					
Any Demolitions 200ft Buffer	1.30** (1.05, 1.61)	1.32** (1.06, 1.63)	1.32** (1.06, 1.63)	1.31** (1.05, 1.62)	1.32** (1.05, 1.62)
Any Demolitions 200ft – 400ft Ring		1.21** (1.03, 1.42)	1.21** (1.03, 1.42)	1.20** (1.02, 1.41)	1.21** (1.02, 1.41)
Any Demolitions 400ft – 600ft Ring			1.03 (0.88, 1.21)	1.03 (0.87, 1.20)	1.03 (0.88, 1.20)
Any Demolitions 600ft – 800ft Ring				0.87 (0.74, 1.03)	0.88 (0.74, 1.04)
Any Demolitions 800ft – 1000ft Ring					1.06 (0.90, 1.23)
Covariates					
Age 1 – 2 Years	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.30)	2.69*** (2.22, 3.30)
Age 3 – 6 Years	1.79*** (1.48, 2.20)	1.79*** (1.48, 2.19)	1.79*** (1.47, 2.19)	1.79*** (1.48, 2.20)	1.79*** (1.48, 2.19)
Male Sex	1.22*** (1.13, 1.31)	1.22*** (1.14, 1.31)	1.22*** (1.14, 1.31)	1.22*** (1.14, 1.31)	1.22*** (1.14, 1.31)
Neighborhood SVI Rank	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)	1.01*** (1.01, 1.02)
May-September	1.32*** (1.23, 1.41)	1.31*** (1.22, 1.40)	1.31*** (1.22, 1.40)	1.31*** (1.22, 1.41)	1.31*** (1.22, 1.41)
Vacancy in 200ft Buffer	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)	1.07*** (1.06, 1.08)
N	49766	49766	49766	49766	49766
Log Likelihood	-13794.83	-13792.29	-13792.21	-13790.95	-13790.69

***p < .01; **p < .05; *p < .1

Table 8. Adjusted ordered logistic regression models examining the relationship between blood lead levels (low, moderate, and severe) and exposure to demolitions (none, one, two or more) within a 400 foot radius in the 45 days before testing, among all tested Detroit children 6 years old and younger, 2014-2016, stratified by season

	Odds Ratios(95% CI) for Categorical Blood Lead Level (Low, Moderate, Severe)	
	Summer	**Not Summer**
	May to September	October to April
Demolition Activity		
1 Demolition	1.35***	0.90
	(1.13, 1.61)	(0.65, 1.21)
2 or More Demolitions	1.59***	0.85
	(1.20, 2.07)	(0.46, 1.44)
Covariates		
Age 1-2	2.65***	2.74***
	(2.04, 3.50)	(2.06, 3.72)
Age 3-6	1.56***	2.10***
	(1.21, 2.07)	(1.58, 2.85)
Male Sex	1.24***	1.19***
	(1.13, 1.37)	(1.07, 1.32)
Neighborhood SVI Rank	1.01***	1.02***
	(1.01, 1.02)	(1.01, 1.02)
Vacancy in 200-foot Buffer	1.07***	1.07***
	(1.05, 1.08)	(1.05, 1.09)
N	24479	25287
Log Likelihood	-7382.36	-6397.71

***p < .01; **p < .05; *p < .1

Table 9. Adjusted ordered logistic regression models examining the relationship between blood lead levels (low, moderate, and severe) and exposure to demolitions (none, one, two or more) within a 400 foot radius in the 45 days before testing, among all tested Detroit children 6 years old and younger, stratified by year (2014 – 2016)

	Odds Ratios(95% CI) for Categorical Blood Lead Level (Low, Moderate, Severe)		
	2014	**2015**	**2016**
Demolition Activity			
1 Demolition	1.49**	1.05	1.19*
	(1.05, 2.07)	(0.74, 1.44)	(0.97, 1.45)
2 or More Demolitions	1.33	0.94	1.73***
	(0.80, 2.09)	(0.50, 1.63)	(1.23, 2.38)
Covariates			
Age 1-2	4.16***	2.76***	2.47***
	(2.37, 8.15)	(1.81, 4.45)	(1.96, 3.16)
Age 3-6	3.06***	2.07***	1.59***
	(1.76, 5.97)	(1.36, 3.32)	(1.26, 2.03)
Male Sex	1.19**	1.19**	1.23***
	(1.02, 1.39)	(1.02, 1.38)	(1.12, 1.34)
Census Tract SVI	1.01***	1.02***	1.01***
	(1.01, 1.02)	(1.01, 1.02)	(1.01, 1.02)
May to September	1.08	1.36***	1.34***
	(0.92, 1.27)	(1.17, 1.58)	(1.22, 1.47)
Vacancy within 200ft	1.08***	1.06***	1.07***
	(1.05, 1.10)	(1.03, 1.08)	(1.06, 1.09)
N	11569	13784	24406
Log Likelihood	-2802.13	-3153.76	-7759.12

***p < .01; **p < .05; *p < .1

Works Cited

Annie E. Casey Foundation. 2011. "Responsible Demolition: A Baltimore Case Study with National Implications." http://www.aecf.org/resources/responsible-demolition-a-baltimore-case-study-with-national-implications/

Detroit Building Authority. 2016. "Scope of Services: Demolition of Residential Structures, Group # 12.12.16A." http://www.buildingdetroit.org/opportunities/open-rfps-and-rfqs/

East Baltimore Development, Inc. 2010. "Operations Protocol for Demolitions and Site Preparation Activities – Revised October 2010." http://www.ebdi.org/uploads/pdfs/EBDIDemolitionProtocol.pdf

Farafel, Mark et al. 2003. "A Study of Urban Housing Demolitions as Sources of Lead in Ambient Dust: Demolition Practices and Exterior Dust Fall." *Environmental Health Perspectives* 111(9): 1228-1234 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241579/

Jacobs, David et al. 2008. "Lead Particulate Deposition from Housing Demolition." Research project for the National Center for Healthy Housing. http://www.nchh.org/Research/ArchivedResearchProjects/LeadDustandHousingDemolition.aspx

Jacobs, David et al. 2013. "Lead and Other Heavy Metals in Dust Fall from Single-Family Housing Demolition." *Public Health Reports* 128(6): 454-462. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3804089/

"Notice of demolition." Chicago Municipal Code §13-124-105. https://chicagocode.org/13-124-015/

"Powers and duties of the Commissioner." Chicago Municipal Code §11-4-2160 https://chicagocode.org/11-4-2160/

Royan, Regina et al. 2016. "Validation of dust suppression protocols for residential demolitions: Preliminary Results – February 2016."

Statement from the U.S. Environmental Protection Agency. Quoted in Ferretti, Christina. "Detroit raises safety in residential razing, empowers neighbors to report contractors." *The Detroit News,* September 8, 2014. http://www.detroitnews.com/story/news/local/wayne-county/2014/09/08/detroit-raises-safety-in-residential-razings-empowers-neighbors-to-report-contractors/15264883/

U.S. Environmental Protection Agency. 1990. "Asbestos NESHAP: Adequately Wet Guidance." https://yosemite.epa.gov/r5/r5ard.nsf/2f86cbca09880b61862565fe00588192/5927b8f7b071523a86256fc7006c5482!OpenDocument