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Lead dustfall from demolition of scattered site family housing: Developing a sampling methodology ☆

Amy Pelka Mucha [a,*], Nicole Stites [b], Anne Evens [c], Patrick M. MacRoy [b], Victoria W. Persky [d], David E. Jacobs [a,e]

[a] Division of Environmental and Occupational Health Sciences, School of Public Health, University of Illinois at Chicago, 2121 W. Taylor (M/C 922), Chicago, IL 60612, USA
[b] Chicago Department of Public Health, Chicago, USA
[c] Center for Neighborhood Technology, Chicago, USA
[d] Division of Epidemiology and Biostatistics, University of Illinois at Chicago, USA
[e] National Center for Healthy Housing, University of Illinois at Chicago, USA

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ABSTRACT

Background: Over 3000 older homes containing lead-based paint are demolished in Chicago each year. While previous studies investigating large multifamily housing demolitions have shown high levels of lead in dustfall, dispersed single-family housing demolition have yet to be assessed. Presently, no standards exist to regulate the extent of lead dustfall from housing demolition.
Objectives: We studied ten residences in Chicago undergoing demolition and debris removal and compared dustfall rates to five standing homes from March to October 2006.
Methods: Dustfall was measured using a modification of APHA Method 502; samplers consisted of plastic buckets filled with 1 l of deionized water, elevated to breathing zone height and placed around the demolition site perimeter. Laboratory analysis consisted of filtration, acid digestion and analysis by ICP/MS.
Results: During demolition, the geometric mean lead dustfall ($n = 43$ at 10 locations) was 64.1 μg Pb/m^2/h (range: 1.3–3902.5), while the geometric mean lead dustfall for areas with no demolition ($n = 18$ at 6 locations) was 12.9 μg Pb/m^2/h (range: 1.8–54.5). This difference was highly statistically significant ($p = 0.0004$). When dust suppression measures were used, dustfall lead levels were lower, although the difference was not statistically significant. The geometric mean lead dustfall with dust suppression ($n = 25$ at five locations) and without ($n = 22$ at six locations) was 48 Pb μg/m^2/h and 74.6 μg Pb/m^2/h, respectively.
Conclusion: Demolition dustfall lead levels are much higher than background levels of lead during demolition of single-family housing and may constitute a yet uncharacterized but important source of lead exposure to nearby residents. Simple dust suppression methods are likely to reduce the contamination considerably.

1. Introduction

The degree of lead exposure in the United States is relatively well understood both on a local and on a national scale from multi-year national surveys, such as the National Health and Nutrition Examination Survey (NHANES) (Brody et al., 2005). The presumption is almost always that the source of that exposure comes from lead in paint. While this is the likely culprit in many cases there still remain areas where similar housing stock, and presumably lead exposure potential does not explain all variability in the pattern of blood lead poisoning. Childhood lead poisoning in the United States decreased dramatically in both frequency and severity after lead was banned in gasoline and paint (CDC, 2002; NAS, 1993). However, lead remains a public and environmental health threat, especially for those living in urban and low socio-economic status areas, where older and less well-maintained housing stock exists. Improper renovation of such housing can create negative short-term impacts by disturbing existing lead paint. Both older housing stock and gentrification are associated with higher blood lead levels in children (Alexander et al., 1999; CDC, 2002; Brody et al., 2005). In Chicago specifically,

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* Corresponding author.
E-mail address: apmucha@uic.edu (A.P. Mucha).

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there are thousands of children who have elevated blood lead levels, with the highest prevalence seen in western and southern neighborhood areas, which are also amongst the most economically disadvantaged communities (Alexander et al., 1999; Evens et al., 2001; Binns et al., 2004).

Previous studies in Baltimore found that demolition of older urban multifamily housing can be a source of significant lead dustfall (Farfel et al., 2003, 2005). Research in Chicago has also shown that there is a significant amount of lead in residential soils (Binns et al., 2004; Finster et al., 2004) that is not entirely attributable to traffic or other known sources. In addition, a previous demolition study of larger public housing structures found that particulate matter was released to a degree that has potential to trigger asthmatic symptoms (Dorevitch et al., 2006).

The City of Chicago provides over 3000 demolition permits each year; this is likely an underestimate of actual demolitions because not all demolition activities have permits. The city requires that demolition sites be fenced and that water be used to wet the debris to minimize dust emissions, although we observed a wide range of compliance with these requirements. A recent survey of the US housing stock by Housing and Urban Development (HUD) shows that there are approximately 7.4 billion ft^2 of interior surfaces and 29.2 billion ft^2 of exterior surfaces coated with lead paint $\geqslant 1\,mg/cm^2$ (Vojta et al., 2002). The potential impact of disturbing this large surface area of lead-based paint is substantial. If a painted surface area of one square foot at $1\,mg/cm^2$ is disturbed and turned into dust, and if that dust is evenly distributed over an average $10\,ft \times 10\,ft$ room floor, the resulting lead loading will be $9300\,\mu g/ft^2$, well above the existing EPA limit of $40\,\mu g/ft^2$.

Sources of lead in urban areas tend to be older housing stock with lead paint (Jacobs et al., 2002) and not usually industrial sources (Levin et al., 2008). In Chicago, the most recent Illinois EPA report showed no violations of the National Ambient Air Quality Standards (NAAQS) for lead (IEPA, 2006). However, ambient air monitoring data indicate that Chicago is in the 95th percentile compared to the rest of the country (US EPA, 2006) and US EPA is currently considering a reduction in the National Ambient Air Quality Standard. However, the source of lead exposure in most children is likely to be lead in paint in older homes and the contaminated dust and soil it generates (Lanphear and Roghmann, 1997). The purpose of this study was to investigate another pathway of exposure from lead in paint to lead in dust that may contribute the still continuing problem of childhood lead poisoning.

Chicago and many other cities have experienced, and will continue to experience, the replacement of older residential buildings with new structures. While this ongoing neighborhood redevelopment removes lead hazards from housing in the long term, the immediate effect of demolition activities that frequently occur in close proximity to occupied buildings has not been definitively assessed. This study quantifies lead in dustfall from demolition of scattered single-family residences, in order to estimate exposures to people who live next door to and in close proximity to demolition and its dust. The study is the first step in a multistep process to assess the impact of demolition activities in a community.

2. Materials and methods

2.1. Sites tested

We tested three types of sites in this study: demolition ($n = 47$ samples on 11 occasions and 10 unique addresses), background ($n = 22$ samples on 7 occasions at 6 unique addresses) and negative control ($n = 2$ at 1 location). Demolition locations were defined as sites where housing demolition and/or demolition debris removal was actively occurring. Background samples were collected to estimate ambient lead dustfall where no active demolition or debris removal was underway within a two block radius. Negative control sampling was done to examine whether our equipment was lead free. For the negative controls, we placed sealed buckets containing 1 l of water in both of the cars that held the sampling equipment and supplies, but was not accessible to outdoor air.

2.2. Demolition sites

A sampling methodology had to be developed in order to find demolition sites to sample, as locations were not known at the start of any sampling day. To identify residential demolition sites, we began with addresses from demolition permits spanning roughly a 2-week period, which are granted by the City of Chicago's Department of Construction and Permits. Direct visual observation determined if demolition was underway or imminent, the latter noticeable by placement of fences around property, presence of equipment, and/or permits posted. Utilizing only this list resulted in successfully finding a demolition site approximately 50% of the time due to the extended length of the demolition permit (30 plus days), the short length of time needed to demolish a home (1–3 days), and the lack of knowledge of the actual start date of demolition. To estimate more precisely the actual start date of demolition, we also obtained additional addresses with a request for gas shutoffs from the utility company. Using both sets of addresses, the success rate in identifying demolition increased to over 80%. Because we also identified demolition sites near previous sites of demolition, we did not have full coverage of the city and our sites tended to concentrate in a few neighborhood areas where demolition was most prevalent, largely on the West side of Chicago.

2.3. Sampling methodology

Lead dustfall was measured by the APHA method 502 as adapted by Farfel et al. (2003). The method consisted of plastic containers with a defined surface area of $506.71\,cm^2$ filled with 1 l of deionized water, lofted to breathing zone height and opened to the atmosphere for a measured period of time. We deployed a sampling team of two people in two cars which generally sampled one demolition per day. All sampling began once the surrounding area (approximately a two block radius) was observed to have no active demolition or debris removal. Sampling occurred approximately one time a week, every other week from March to October 2006, weather permitting. Sampling was either halted or not conducted when precipitation occurred. Background sampling generally occurred on days in which a demolition site was not identified and in areas in which no active demolition was underway and where demolition sampling was going to occur or had already been done.

Once a demolition site was identified, samplers were set up using already assembled apparatus. The apparatus was placed on public property at the building perimeter surrounding the location of interest. Samplers were attached to available trees, light poles, and utility poles. The distance from the sites varied but was approximately 5 m from demolition activity. Once the apparatus was secured at approximately 2 m (breathing level) above ground level, 1 l of deionized water was poured into the bucket and the collection time was started. A nominal minimum of 4 samples were used for each demolition site, one at each corner of the plot. As shown in Fig. 1, we placed a sticker on the