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The effectiveness of low-cost soil treatments to reduce soil and dust lead hazards: The Boston lead safe yards low cost lead in soil treatment, demonstration and evaluation

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Abstract

The Boston lead safe yards low cost lead in soil treatment, demonstration, and evaluation was developed to explore the viability and effectiveness of low-cost soil interventions to reduce exposure to soil lead hazards. Buildings that had been abated for lead to Massachusetts's deleading standards in the previous 5 yrs and met other program requirements were recruited for the evaluation. Following individual property assessments, yards were treated with application of ground coverings and ground barriers in 2000–2001 and followed up at 1 yr. The treatment cost ranged from $1095 to $5643 with an average of $2798. Soil lead levels at the building dripline, measured with a field-portable X-ray fluorescence analyzer (Niton Model 702 Spectrum Analyzer), dropped from 2021 PPM at baseline to 206 PPM at 1-yr follow-up. Most of the barrier treatments continued to block access to the lead-contaminated soil at 1 yr. At the follow-up, few properties with grass treatment had areas that were completely bare, but 28% had more than a small amount of treated areas bare. Treatments were effective in reducing entryway dust lead in the rear of the building if the residents reported they had maintained the yard treatments. Each additional yard work activity reported was predicted to lower 1-yr floor dust lead loading at the rear common/main and dwelling unit entries by about 20%. Each additional 100 ft^2 of yard treated was predicted to lower 1-yr floor dust loading at the rear dwelling unit entry by 19%. Treatments did not show a dust lead effect at 1 yr in the front entryway of the building, but the investigators believe that this may be due to the effect of resident cleaning overshadowing the treatment effect.

Keywords: Soil lead hazard; Soil treatment; Lead-contaminated soil; Low-cost soil intervention; Barrier treatment

1. Introduction

The contribution of lead-contaminated soil to children's blood lead levels has been clearly established (Lanphear et al., 1998; Clark et al., 1991; Mielke and Reagan, 1998). Children may be exposed to soil lead directly when playing outdoors or indirectly through track-in into the home. Stanek and Calabrese (1995) and Murgueytio et al. (1998) estimated that the source of 30–40% of total indoor dust is outdoor soil. Reducing soil lead levels or improving the condition of the yard surface cover may lessen direct and indirect soil lead effects.

A number of studies have examined effectiveness of soil lead interventions on soil and dust lead hazards (Aschengrau et al., 1994; Binns et al., 2004; Farrell et al., 1998; Lanphear et al., 2003; Weitzman et al., 1993). The USEPA Three-City Soil Abatement Study found that in Boston, soil abatement resulted in significant declines in children's blood lead levels, while there was little effect of abatement

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in Baltimore or Cincinnati (Aschengrau et al., 1994). Aschengrau and colleagues further found that within the Boston study group some subpopulations gained little or no benefit from soil abatement, such as children living in apartments with interior floor dust lead levels consistently above the baseline median of 90 μg/ft^2 (as measured by vacuum sampling). This study and others suggested that when soil abatement was conducted in conjunction with interior lead treatments or in homes where the soil was the primary source of lead exposure the soil treatments were associated with declines in interior dust lead levels and the health benefits of soil treatments were greatest (Aschengrau et al., 1994, 1997; Lanphear et al., 1998).

Many of the early soil intervention studies abated soil by removing and replacing the top soil layers (Aschengrau et al., 1994; Farrell et al., 1998; US EPA, 1996; von Lindern et al., 2003; Weitzman et al., 1993). These interventions were relatively expensive ($9600 per yard in 1990) (Weitzman et al., 1993), so lower cost options such as in-place management (grass, sod, mulch) have been explored subsequently. However, the efficacy of these treatments has been questioned because grass seed or sod may not hold up over time unless owners maintain their yards. Clark et al. found that properties that underwent interior lead treatments with generally lower-cost soil lead treatments had lower follow-up exterior entry, dwelling unit entry, and interior floor dust lead levels than comparable properties where soil was not treated (Clark et al., 2004). Binns et al. (2004) had mixed results with low-cost soil interventions in Chicago. In that study, geometric mean (GM) entry floor dust lead loading decreased from baseline to 1 yr for the 14 properties with raised garden boxes but increased for the 23 properties treated with ground covering/barriers but no raised garden boxes.

The Boston Lead Safe Yards Low Cost Lead in Soil Treatment, Demonstration and Evaluation (Lead-Safe Yards Evaluation) was developed to examine the viability and effectiveness of low-cost soil interventions to reduce residential exposure to soil lead hazards. Properties were followed from preintervention to 1 yr after the baseline visit. Effectiveness was assessed with entry dust lead loadings, field-portable XRF soil lead concentrations, and treatment integrity at 1-yr follow-up by visual inspection. Track-in potential was also examined with the dust lead loading accumulated per day on a dust mat placed at the front building entry (for approximately 2 wks).

2. Methods

2.1. Overall design

The Lead Safe Yards Evaluation was developed to examine the effectiveness of lead safe yard treatments in properties that had been deleaded or abated for lead to Massachusetts' standards in the previous 5 yrs. US Environmental Protection Agency (EPA) Region I, Lead-Safe Boston (LSB), and the US Department of Housing and Urban Development (HUD) funded the evaluation. The National Center for Healthy Housing (NCHH) was the project coordinator and evaluator. Properties from three lead-safe yards projects with different funding sources were recruited for this evaluation:

1. An EPA Environmental Monitoring for Public Access and Community Tracking (EMPACT) funded project, conducted in the Roxbury and North Dorchester neighborhood, in partnership with the Dudley Street Neighborhood Initiative (DSNI).
2. A 1994 HUD Lead Hazard Control Grant funded project managed by the City of Boston's Department of Neighborhood Development's LSB Program in Dorchester and Roxbury.
3. A 1994 HUD Lead Hazard Control Grant funded project managed by the Boston Public Health Commission's Office of Environmental Health and LSB in the Humphrey's Place neighborhood of Dorchester (HP).

The soil sampling, treatment, and maintenance strategies used in these projects are documented in the US EPA Lead Safe Yards publication (US EPA, 2001a). The levels of lead in soil from the EMPACT funded project were documented in a previous publication (Litt et al., 2002).

The Lead Safe Yards team, consisting of representatives from Region I EPA, LSB, Office of Environmental Health, Boston University, DSNI, and NCHH met regularly to coordinate efforts during the development and execution of the evaluation.

Baseline sampling was conducted from April 2000 to October 2001. Interventions were conducted from May 2000 to November 2001. On average, treatments were started 13 wks from the baseline visit and were completed in 4 wks. One-year follow-up visits were conducted from July to November 2001, ranging from 12 to 15 months after the baseline visit.

The Boston Public Health Commission's Office of Environmental Health submitted the application for IRB review to the Boston University School of Medicine, where it was found to be exempt. Property owners and tenants gave written informed consent to participate. All property owners and tenants were informed in writing of the results of dust, mat, and soil testing for their property and referred to the Office of Environmental Health for assistance in lead dust control if interior dust lead levels in their properties were over federal standards.

2.2. Enrollment criteria

The following properties qualified for evaluation inclusion: (1) properties deleaded by the LSB 1994 HUD Grant Program; (2) properties located in the HP neighborhood of Dorchester and deleaded by Boston's Office of Environmental Health in 1999–2000; or (3) DSNI properties located in the Brownfield catchment area, and abated after 1994 with a Massachusetts Certificate of Full Compliance.

Three additional requirements had to be met: (1) the owner had current homeowner's insurance; (2) the owner signed a consent to participate, which included agreement to clear the yard of trash and debris prior to treatment; and (3) the owner had paid property taxes. LSB property owners were required to have a child living on the property and to have paid water and sewer bills or have made provisions to do so.

Sixty property owners applied for inclusion and signed the consent form, but only 47 were enrolled in the study and received soil treatments. One property was de-enrolled before the 1-yr visit following a change in ownership.

Properties included in this analysis were required to have a full set of data, including soil lead measurement of the dripline areas with AA analysis at baseline, details of treatment, a completed resident questionnaire at 1 yr, an exterior building assessment at baseline and 1 yr, and exterior and common/main dust lead results from the specific entry (i.e., front or rear) at baseline and 1 yr. Forty-one properties met the inclusion criteria for this paper. Twenty-one were LSB properties, five were HP, and 15 were DSNI properties.