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A critical evaluation of public health programs at the Bunker Hill Superfund site

John F. Rosen*

Division of Environmental Sciences, The Children's Hospital at Montefiore, The Albert Einstein College of Medicine, Bronx, NY 10467, USA

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Abstract

Since 1983, the Bunker Hill Superfund site (BHSS) has been the second largest on US Environmental Protection Agency's (EPA) National Priority List for cleanup. Contaminants include millions of tons of Pb, Cd, Hg and As. In 1974, following a bag house fire, 22.1% of young children had blood lead levels >80 μg/dl. In the early 1980s to the present, EPA initiated the cleanup of exterior residential soils and the smelter complex. In 1999, The National Geological Service confirmed that heavy metal pollution had extended from BHSS to Lake Coeur d'Alene (already known earlier) all the way to the Spokane River in Washington State via water borne tributaries linking Idaho and Washington States. This report focuses on public health programs and their results initiated by Federal and State agencies at the BHSS. These programs include blood lead screening, educational programs, exploratory dust control plans, and land transactions. These programs and their results are then evaluated, assessed and critically discussed. The conclusion of this critical evaluation assessment is that the protection of public health has not been adequately addressed or protected by Federal and State agencies.

Keywords: Lead; Education; Blood lead concentrations; Land transactions; Leaded dust; Lead poisoning

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1. Introduction

The Silver Valley was the center of one of the most productive mining areas in the world. Deposits of gold, silver, zinc, lead, and associated metals have been mined in the upper Coeur d'Alene (CDA) Basin for over a century. This specific area is known as the Silver Valley. During the past century, substantial amounts of industrial wastes, including metal toxicants, have been discharged into the environment documented in the US and CDA Tribe's First Set of Proposed Findings of Facts (US District Court for the District of Idaho, April 6, 2001). These contaminants consist of millions of tons of lead and other metals, which have been washed downstream via the CDA River and its tributaries as far as Spokane, Washington, approximately 75 miles distant from the Bunker Hill Superfund site (BHSS) or the 'Box,' so designated in 1983. The BHSS covers 21 square miles and includes the former smelter complex near Kellogg where the worst outbreak of child-

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*Tel.: +1-718-920-5016; fax: +1-718-920-4377.
E-mail address: jrosen5@ix.netcom.com (J.F. Rosen).

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hood lead poisoning known to have taken place in the US, occurred in the early 1970s. Public health and remedial activities have been on-going at BHSS for over two decades.

The public health programs presented and then evaluated include screening of children for lead poisoning, educational initiatives, the methods and results used to examine contamination in homes and schools of residents inside the 'Box,' measurement methods to quantify the levels of lead inside residential areas and schools, and then approaches to decontaminate homes of lead. Finally, land transaction-programmatic responsibilities planned by the Panhandle Health District (PHD) will be described.

2. Methods

In preparation for writing this article, I reviewed several Federal Documents, multiple Documents published by the State of Idaho, and several peer reviewed articles that were published in journals. These documents and articles are referred to in the text and included in a bibliography at the end of this article. The credentials which allow me to critically review the programs at BHSS are given in Appendix A.

3. Results

The results in this section are a summary of public health programs and resultant data that were found in Federal Documents and Documents published by various agencies of the State of Idaho. Some of the Documents published by the State of Idaho combine public health programs and what the State referred to as Institutional Control Programs (ICP). For purposes of clarity, most of these programs, unless specifically identified in a different context, are referred to as ICP Programs.

The stated purpose of the ICP Programs is to 'locally enforce rules and regulations designed to ensure the integrity of clean soil and other protective barriers placed over contaminants left...' throughout the BHSS (IDDHW, 1999; IDDHW/DEQ, 1999; US EPA, 2000a), An additional cornerstone of the ICP Programs is 'to protect public health and assist in local land transactions' (IDDHW, 1999). A third principle of the ICP Programs is to intervene to enhance the public's health by education and consultation. A fourth foundation underlying these Programs is to provide homeowners with mops, and high efficiency vacuum cleaners as 'dust settles' and to provide 'protective barriers...' (PHD, 1995). A fifth goal of these Programs is to screen for lead in blood of expectant mothers to reduce exposure for these women living at the site' (IDDHW, 1999). Lastly, a Program was implemented as a 'service to help reduce lead levels in area children' (IDDHW, 1999). Specifics of the Programs are outlined below.

3.1. Blood lead levels

The aims of this Program are to screen blood lead levels in children and expectant mothers. Field workers were tasked to obtain census data on participants and non-participants in these annual screening surveys. If a blood lead level in a child was greater than 9 μg/dl, a follow-up visit was to be made by a public health nurse or an environmental specialist from the PHD. As stated above, such surveys were undertaken to 'reduce lead levels' in children and to 'reduce' exposure in pregnant women (PHD, 1995; IDDHW, 1999).

As of 1999 (IDDHW, 1999), the PHD indicated that 95% of all children are achieving blood lead concentrations <10 μg/dl and $<1\%$ of children have blood lead levels >15 μg/dl.

To my knowledge, the PHD has not reported blood lead values for expectant mothers as outlined in the ICP Program.

3.2. Educational aspects of the ICP

Educational meetings with parents were planned, coupled to distribution of educational materials. Similar paradigms were also planned for school children, school superintendents, and health care providers in the community. This program was constructed to be the cornerstone of an intervention program to protect the public's health. Providing educational materials to and blood lead tests for expectant mothers was aimed at reducing excessive exposure to lead in these at risk women.

There does not appear to be any data to support the efficacy or lack thereof of any of these teaching programs, such as the number of encounters with each group, an independent assessment of the quality of the teaching materials, or any feed-back from the target audiences of these educational programs to include potential knowledge thereby gained. Similarly, no such data are apparently available from blood lead screening of expectant mothers.

3.3. Dust lead protocols in the homes of BHSS residents: methodologies and implementation

Chronologically, the plan in 1991 was to obtain 'grab' samples of dust from home vacuum cleaners to be followed by vacuuming the home interior with a high efficiency particulate vacuum cleaner. Then, floor and upholstery were shampooed 3 times with a detergent, which was not specified, with a 1-h interval between shampooing. Eighteen homes were sampled via removal of dust from the home's vacuum cleaner. The range in lead content of household dusts, prior to vacuuming and shampooing, was 780–18,293 ppm, The yield of total lead removed by the above protocol was 2.0–13.6%. This report stated that the effect of remediation of the interior of homes was 'highly variable,'(IDDHW, 1991).

The plan adopted in 1999 (IDDHW/DEQ, 1999) had two aims: the first was to evaluate dust lead in Kellogg and Wardner homes by the 'grab' sample vacuum cleaner collection method (IDDHW, 1991) from homes whose outside soil had been remediated, never remediated or was having on-going remediation. Twenty to forty four percent of these homes had dust lead values (to be discussed below) greater than 1000 ppm, The second aim of this plan, to be carried out by the PHD, was to locally enforce a set of regulations designed to ensure the integrity of clean soil and *put into place other protective barriers*. The apparent purpose was to contain contaminants throughout the BHSS site and 'to protect public health.' Results of this dual faceted program, other than those cited above, are not available.

Sampling of some schools in the Silver Valley was carried out in 2000 (IDDHW/DEQ, 2000). For this task as well, 'grab' samples were obtained from the school(s) at a time of day which may not have represented the major time of 'traffic' in and out of the schools. The range of soil lead values at the Kellogg Middle School ranged from 634 to 17,115 ppm. At the Silver Hills Middle School, soil lead values ranged from 142 to 17,506 ppm. At a greenhouse within the Silver Hills Middle School, soil lead values were as high as 1143 ppm in the 0–6 in. core and as a high as 30,920 ppm in the 6–12 in. core. Values for arsenic, a potent human carcinogen, ranged from 33.3 to 1049 ppm in the same area of the school (IDDHW/DEQ/EPA Region X, 2001).

3.4. Land transactions

Another aim of the ICP-Health Intervention Programs was for the PDH to 'assist local land transactions within the Superfund site'(IDDHW, 1999). This endeavor also permits the PHD to regulate and provide assistance with construction and renovation projects on building interiors, basements and crawl spaces. Generally, the PHD states that the 'fundamental purpose of the ICP is to protect public health and assist local land transactions within the Superfund site.' There does not appear to be any data relating to these activities.

4. Discussion

Basic concepts of lead's pathways and its bioavailability to susceptible populations provide a background to the discussion of public health programs that follows below.

4.1. Pathways of lead exposure for children and adults

The pathways to lead-contaminated homes are obvious; but these pathways will be summarized briefly. The contributions to lead-contaminated homes, directly into household dust, that entirely pervades every aspect of a home's living environment, to floor, rugs, clothes, skin, toys, hair, scalp, linoleum, wooded surfaces, ceilings, walls, attics, kitchen ware, kitchen appliances, attics, *include* (not exclusively), exterior soil and dust from yards, cross-contamination from a neighbor's yard, walking into homes with shoes and all clothing contaminated from the external world, during exterior remediation, dust storms, local flooding (as in 1996 and 1997), uncovered and uncontrolled contaminated soil from the Superfund site and airborne lead particles from Superfund operations. From a public health point of view, air monitoring on and off site should be carried out (at least) periodically.

Several analyses have been carried out to estimate the contributions to lead-contaminated house dust and soil to people's homes and ultimately as a major source of lead exposure and poisoning of young children (see references below). A pooled analysis of 12 epidemiologic studies demonstrated that lead-contaminated house dust in children 1–6 years of age (and in adolescent and adult subjects), is the major source of lead exposure for children (Lanphear et al., 1998a). This and other studies further demonstrate the very strong relationship between interior dust lead loading and children's blood lead values (Lanphear et al., 1996a,c; Lanphear and Roghmann, 1997; Lanphear et al., 1998a,b, 1999, 2000, 2002). Clearly, site-specific factors, such as the external remediation in Bunker Hill, the weather, nutrition and the life-styles of the community are critical factors that influence blood lead values at a given level of exposure. Structural equation modeling has also been used to definitively characterize pathways of lead intake by young children, ultimately leading to elevations in blood lead values (Lanphear and Roghmann, 1997). These and other data demonstrated that dust lead levels in the home were directly related to blood lead levels in children (Lanphear and Roghmann, 1997; Lanphear et al., 1998b; Sterling et al., 1999). Currently, it is generally recognized that dust lead in home interiors, *measured as lead loading in micrograms of lead per unit area* (*square foot*), *compared with dust lead concentrations in a mass of household dust* (Milar and Mushak, 1982; Adgate et al., 1995; Emond et al., 1997; Sterling et al., 1999 and the above references), is the best predictor of blood lead concentrations in young children. Moreover, national regulations have established lead loading as the metric to employ in the assessment of lead in household dust (US EPA, 2001).

4.2. Bioavailability of lead in household dust

The bioavailability of lead from household dust has been unequivocally demonstrated. The resting pH of gastric juice in children is approximately 1.0 and sustainable gastric acid output with stimulation approaches 150 milli-equivalents per liter. In addition to hydrochloric acid, the gastric contents also contain multiple enzymes and other electrolytes. The complex interactions of the gastrointestinal tract with lead are shown in the in vivo behavior of various chemical forms of lead. Lead sulfide, for example, a chemical form of lead considered to be less bioavailable than the chloride, sulfate or organic chelates, has a solubility product constant (KSP) of 3.4×10^{-28}; but it is extensively solubilized by acidic gastric juice to lead chloride, $\mathrm{KSP}=10^{-4}$ (Healy et al., 1982). Thus, this type of reactivity with gastric juices and contents (enzymes) plays a highly significant role in the bioavailability of various lead species. Moreover, it has already been demonstrated in adults that lead sulfide, ingested during the fasting state or with meals, was absorbed in the same amount as lead chloride or the cysteine complex (Rabinowitz et al., 1980). In this regard, soil from BHSS, 'spiked' with a stable isotope of lead, has been shown to be readily absorbed from the gastrointestinal tract of adult volunteers. In the absence of meals, the amount of label absorbed was approximately 26% and, in the presence of meals, 2.5% of the label was absorbed (Maddaloni et al., 1998).

In terms of lead in soil and dust, studies have shown that for each 1000 ppm concentration of lead, the increase in the blood lead values of children rises *on average* by 3.5–5 μg/dl (CDC, 1991; Bornschein et al., 1986; Bornschein et al., 1989; Clark et al., 1987; Gallacher et al., 1984). Additional studies (Mushak, 1991; Gulson et al., 1994) have also shown that particle size plays an important role in the absorption of lead from the gastrointestinal tract: particle sizes less than 100 μm, especially less than 50 μm, markedly enhance the absorption of lead (Bornschein et al., 1989; Duggan et al., 1985). Young children are at further risk as a result of normal hand-to-mouth activity, as related to particle sizes of lead in various media.

Hand-to-mouth activity is the most common pathway for children to develop lead poisoning by ingestion of leaded dust in the home environment. It has been demonstrated that lead at <200 μm, adheres most avidly to the skin of children (Bornschein et al., 1986, 1989; Clark et al., 1987; Duggan et al., 1985).

4.3. Blood lead levels reported in the Silver Valley from 1988 to 1999

Blood lead surveys are useful tools at lead sites to help identify key site-specific exposure pathways and thereby direct primary care providers to *individual children*, who need immediate medical and environmental intervention to minimize lead exposure and to reduce blood lead concentrations (CDC, 1985, 1991, 1997). Screening programs can be extremely beneficial in *identifying individual children* with elevated blood lead values and identifying *individual lead poisoned children* for referral to medical professionals for examination and evaluation. Blood surveys are important to carry out as indices of long-term risk where exposure conditions are expected to change over time. Surveys of this type should be considered a '*snapshot*' of on-going exposure under a specific set of circumstances at a specific point in time.

Blood lead surveys of the nature carried out at the BHSS do not serve the purpose of defining the prevalence of childhood lead poisoning in this or any other community. The utility of blood lead testing results to determine the epidemiological prevalence of childhood lead poisoning in a community must consider the representativeness of the population undergoing testing, the statistical design of the survey, and other critical factors, such as the age of children, season of the year, stability of the sample, randomization of the sample, construction of a statistically stratified sample to yield an epidemiologically sound survey to characterize the true prevalence of lead poisoning in any population (US EPA, 2000b). Unless these principles are followed, a biased sample may result.

Other concerns are also expressed relating to the basic principles of management of lead poisoned children at the BHSS. By definition, childhood lead poisoning is a disease in the pediatric age group; follow-up by a pediatrician (health care provider) is indicated (CDC, 1985, 1991, 1997). Apparently, this medical task is being undertaken by a Public Health Nurse or an Environmental Specialist. The management of this disease does require collaboration by the primary health care provider and the local department of health; but it is inappropriate for primary health care providers not to participate in the management of this childhood disease, namely, the clinical management of a lead poisoned child (CDC, 1985, 1991, 1997).

Moreover, for the purpose of identifying individual lead poisoned children, there appears to be disagreement concerning the number of children who have blood lead levels >9 μg/dl. The IDDHW states that 4.8% of children had blood lead levels >9 μg/dl in 1998 (IDDHW, 1999). In contrast, the Five Year Study Review (IDDHW/DEQ, 2000) states that 29.5% of children, 1–2 years old, had blood lead levels >9 μg/dl in 1999. The latter percentage (29.5%) is consistent with 29% of children, who had blood lead concentrations equal to or greater than 10 μg/dl, at the BHSS from 1996 to 1999 (IDDHW/DEQ/US EPA Region X, 2000). The statistics reported by the PHD are perplexing and open to question.

4.4. Dust lead levels in homes at the BHSS

As of this writing, 91 of 1547 or 5.9% of home interiors have been sampled for lead at the BHSS. This small fraction of homes fails to answer a critical public health question: what is the extent of toxicant contamination in homes within the BHSS? (Hirschhorn, 1998a,b, 1999c; IDDHW, 1991). IDDHW reported in 1991 that only 2–13% of lead was removed from the interiors of homes by the methods described above. There are several explanations for this failure to decontaminate homes by the methods employed (IDDHW, 1991). Samples of dust were removed from home vacuum cleaners as the baseline sample for lead in household dust. This method collects, in addition to leaded dust, non-lead dust and non-lead dirt. When dust is *collected per unit area* (1 *square foot*), *not as lead concentration in ppm* (IDDHW, 1991), this collection is independent of non-lead dust and dirt. Lead measurements per unit area (lead loading) are accepted as a far more accurate indicator of blood lead concentrations (Milar and Mushak, 1982; all above references by Lanphear et al., 1996b); and the latter metric of lead loading is the only metric for which the US EPA has set national regulations (US EPA, 2001). Hence, the collection method used in 1991 (IDDHW) was a non-standardized method for which no national standards existed then, nor do they exist in 2002. Lead loading is the metric employed by US Housing and Urban Development in 1990 (US HUD, 1990) and is currently the metric endorsed by the US EPA (US EPA, 2001). Lead standards for floors, window sills and window wells were 800, 500 and 200 $\mu g/ft^2$, respectively, according to regulations in 1990; and these have recently been revised downward to 400, 250 and 40 $\mu g/ft^2$, respectively (US EPA, 2001). The latter are the relevant standards for home interiors now; and the previous regulations defined standards in 1990. None of these national regulations employed concentration measurements for lead in ppm.

The method used in 1991 to de-lead home interiors (IDDHW, 1991) was flawed and the method used to clean homes of contaminants appears to be responsible, in large part, for the very low yields reported. In 1991, IDDHW used a shampoo that was not specified. It was known in 1982 (Milar and Mushak) that Calgon (or other powdered dishwashing detergents) were highly effective in removing lead from home interiors. Calgon (or its powdered equivalent) coats particulate lead with polyphosphate groups and then permits easy removal of lead with a detergent. Using a high efficiency vacuum cleaner followed by a Calgon wash, a period of drying (up to 24 h), followed by a detergent wash (and a drying period up to 24 h) yielded a lead removal value of 91% (Milar and Mushak, 1982); and, in contrast, using a detergent only, the amount of lead removed was 38%. The use of Calgon and then a detergent, a long drying period, Calgon, then detergent, and a long drying period (24 h) can be repeated 3–4 times. If this technique had been used in 1991, the likely results could have been far better than 2–13%.

There is a perplexing statement referring to the use of 'barriers' in previous state documents (PHD, 1995; IDDHW, 1999). These barriers are not defined and hence, their purpose is unclear. Did the State mean physical barriers or both internal and external barriers of some kind? Placement of air filtration units in all windows of all homes within the extent of contamination of the BHSS could be highly meaningful, particularly prior to interior home clean-ups (Hirschhorn, 1998a,b, 1999c). Given the dollars spent to date on clean up of contaminated soil outside of people's homes, placement of air filtration units (estimated cost: $l.0 million) followed by appropriate methods to decontaminate homes should be instituted promptly to protect the public's health from multiple toxicants.

4.5. Educational programs

In relation to these and other aspects of the Health Intervention-ICP Programs, independent oversight and assessment is lacking. In addition, hard and credible data are lacking as well, so that the efficacy of these programs is impossible to discern. In terms of educational programs, there are apparently no data on the number of students, parents, health care providers, superintendents or expectant mothers, who have been reached by either educational materials or direct consultation. Moreover, the quality of the educational materials themselves has not been independently evaluated. Thus, the efficacy of educational programs is unknown. If a sub-set of parents had been randomly selected and provided with the most comprehensive educational program, compared to a sub-set of parents who received basic information only, and parents in each group took an informational test prospectively over time, some hard data might have been obtained concerning the success or lack of success of these educational programs. Similar subsets of students, teachers, school principles, and health care providers should also have entered assessment programs to discover the successes and failures of the educational programs. By so doing, educational programs could have been readily strengthened. Because such data are absent, neither success nor failure can be claimed for any of the teaching paradigms.

4.6. Land transactions

It is unusual for a department of health, the PHD, to be the reporting agency for Realtors, sellers, and buyers in terms of obtaining copies of lead testing of specific properties (IDDHW, 1999; PHD, 1995). Such an 'economic' role is more appropriately the responsibility of a Board of Realtors. It is reasonable to suggest that this section of the Health Intervention-ICP Program renders the PHD to be in a position without any legal standing, legal jurisdiction, required certification, and in reality, represents a potential conflict of interest. Why the PHD initially included this responsibility (IDDHW, 1999; PHD, 1995) is unknown; and this economic task appears to be beyond the health focus of a department of health. Ultimately, the PHD withdrew all responsibility for this task (PHD, 1999), after initially including it in the ICP Program. Furthermore, these initially proposed tasks are governed by Federal law (Title X), not by local jurisdictions.

5. Conclusions

Credible scientific data has not yet been presented to demonstrate the impact of the Programs outlined in Section 3 (interpretation of blood lead values, educational programs, dust lead measurements and de-contamination of homes, placement of unspecified barriers, and educational programs in the community); and there do not appear to be any independent assessments of the content of the Programs as summarized. Nonetheless, success has been claimed in reducing dust lead levels in the interior of homes. Furthermore, success has been claimed for reducing blood lead values in young children in the absence of a randomized, stratified and prospective examination of blood lead concentrations within a context of an epidemiologically credible design. Although blood lead values may well have declined as a result of control of the contaminating sources of mining and smelting at the BHSS, reductions in blood lead concentrations cannot serve the function of assessing the successes or failures of soil remediation at the BHSS. In other instances, such as contaminants in home interiors, methods were not employed that meet national standards and inappropriate techniques were used to remove very small fractions of toxic lead in the few homes that were tested and 'de-contaminated.' In brief, methodological shortcomings and the lack of substantiating scientific data to assess the efficacy of the Health Intervention-ICP Programs, collectively, reflect compromises to protect and to enhance the health of susceptible populations at the BHSS.

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Appendix A: Expertise in Environmental Sciences in Pediatrics

I am a Professor of Pediatrics and Head of the Division of Environmental Sciences at the Children's Hospital at Montefiore and the Albert Einstein College of Medicine. In this position, I have directly and indirectly treated over 23,000 lead poisoned children over the past three decades. Our group of 18 health professionals is focused on the treatment, management, diagnosis and prevention of childhood lead poisoning. Our group has published approximately 100 peer-reviewed articles on this subject.

I have written three Public Health Programs for residents of all ages at two Superfund sites in the US, where lead was the predominant toxicant. These sites include Throop and Palmerton, PA. I have also written a medical monitoring program for 600,000 children in New York City (collaboratively with Drs A. McBride and P. Landrigan); and I have written public health programs for 90,000 children in Chicago's Section 8 housing. Moreover, I have worked with the US Department of Justice and the US EPA on 5 cases, in which I was their medical expert on health issues in children and adults, as related to current and latent effects of excessive exposure to lead and other toxicant metals.

From 1997 to 1999, I served as a Technical Assistance Advisor, funded by the US EPA, in collaboration with the People's Action Coalition in Kellogg, Idaho. At the end of that funding period, I served as a volunteer in a very similar capacity. During 18 trips to the Silver Valley from 1997 to the present, I also saw several families in the context of confidential medical consultations.

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