Environmental Research 161 (2018) 181–187

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Improving human health outcomes with a low-cost intervention to reduce exposures from lead acid battery recycling: Dong Mai, Vietnam

Bret Ericson[a,b,c,*], Thi To Duong[d], John Keith[a], Trong Cuu Nguyen[e], Deborah Havens[f], William Daniell[f], Catherine J. Karr[f], Doan Ngoc Hai[h], Lo Van Tung[h], Tran Thi Nhi Ha[h], Brian Wilson[g], David Hanrahan[a], Gerry Croteau[f], Mark Patrick Taylor[b]

[a] Pure Earth, 475 Riverside Drive, Suite 860, New York, NY 10025, USA
[b] Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, NSW 2109, Australia
[c] College of Global Public Health, New York University, 41 East 11th Street, New York, NY 10003, USA
[d] Centre for Environment and Community Development, House No.23, Alley No.1104, De La Thanh street, Hanoi, Vietnam
[e] Department of Planning and Finance, Vietnam Environment Administration, 10 Ton That Thuyet Street, Hanoi, Vietnam
[f] Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, WA 98195, USA
[g] International Lead Management Centre, 525 Meridian Parkway, Suite 100, Research Triangle Park, NC 27713, USA
[h] National Institute of Occupational and Environmental Health, 57. Le Quy Don, Hai Ba Trung, Ha Noi, Vietnam

ARTICLE INFO

Keywords:
Soil lead dust intervention
Education
House dust intervention
Used lead acid battery
Low- and middle-income countries

ABSTRACT

This study details the first comprehensive evaluation of the efficacy of a soil lead mitigation project in Dong Mai village, Vietnam. The village's population had been subject to severe lead poisoning for at least a decade as a result of informal Used Lead Acid Battery (ULAB) recycling. Between July 2013 to February 2015, Pure Earth and the Centre for Environment and Community Development (Hanoi, Vietnam) implemented a multi-faceted environmental and human health intervention. The intervention consisted of a series of institutional and low-cost engineering controls including the capping of lead contaminated surface soils, cleaning of home interiors, an education campaign and the construction of a work-clothes changing and bathing facility. The mitigation project resulted in substantial declines in human and environmental lead levels. Remediated home yard and garden areas decreased from an average surface soil concentration of 3940 mg/kg to < 100 mg/kg. One year after the intervention, blood lead levels in children (< 6 years old) were reduced by an average of 67%—from a median of 40.4 μg/dL to 13.3 μg/dL. The Dong Mai project resulted in significantly decreased environmental and biological lead levels demonstrating that low-cost, rapid and well-coordinated interventions could be readily applied elsewhere to significantly reduce preventable human health harm.

1. Introduction

In high-income countries (HICs), regulatory controls, notably bans on lead in widely used and available products (e.g. residential paint, gasoline), have resulted in significant lowering of population blood lead levels (Kristensen et al., 2017; Needleman, 2004; Schwartz and Pitcher, 1989). In Low and Middle Income Countries (LMICs) key sources of environmental lead exposure include mining (both legacy and active), used lead acid battery (ULAB) processing, and lead-based ceramic glazes, among other sources (Farías et al., 2014; Lo et al., 2012; Meyer et al., 2008; Yabe et al., 2015). Used lead acid battery processing in particular is known to cause significant environmental contamination and human health exposure (Farías et al., 2014; Lo et al., 2012; Meyer et al., 2008; Yabe et al., 2015). In the context of limited regulatory oversight the extent and severity of lead poisoning in LMICs is less well documented but is suspected to be prevalent (Braithwaite, 2006; Chatham-Stephens et al., 2013; Dowling et al., 2016; Ericson et al., 2013). Lead is a known neurotoxicant and can result in an IQ decrement in children and cardiovascular disease in adults, among other adverse health outcomes (ATSDR, 2007). On a societal level, lead exposure has been associated with increased levels of aggravated assault and decreased economic output (Gould, 2009; Mielke and Zahran, 2012; Prüss-Üstün et al., 2010).

Multiple studies have documented very high blood lead levels (BLLs) in communities where informal ULAB processing occurs (Daniell et al., 2015; Haefliger et al., 2009; Matte et al., 1991). This activity is typically undertaken in residential areas and is characterized by poor or no hazard control and migration of material offsite (Shen et al., 2016).

* Corresponding author at: Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, NSW 2109, Australia.
E-mail address: bret@pureearth.org (B. Ericson).

https://doi.org/10.1016/j.envres.2017.10.042
Received 1 August 2017; Received in revised form 20 September 2017; Accepted 24 October 2017
0013-9351/ © 2017 Elsevier Inc. All rights reserved.

A recent study has estimated that between 10,599 to 29,241 such sites exist in 90 different LMICs, placing the health of 6–16 million people at risk (Ericson et al., 2016). A limited number of projects have been executed at comparable lead contaminated sites to mitigate exposures, with most utilizing a combination of in situ and ex situ engineering controls coupled with community education (Laidlaw et al., 2016; Pure Earth, 2017). However, there is an absence of peer-reviewed studies evaluating the efficacy of remediation strategies at informal ULAB and remediation more broadly in LMICs.

1.1. Study location and background

In Vietnam, informal industry including ULAB recycling is commonly centered in 'craft villages'. These small to medium sized areas produce a range of consumer and industrial goods and are typically characterized by inadequate waste management practices (Mahanty and Dang, 2013). Craft village industrial activities are also characteristically household-based, with individual homeowners often working in concert to complete sequential tasks in the production of a single good (Mahanty and Dang, 2013). This research focuses on the outcomes of a multi-faceted intervention to reduce lead exposures in the Dong Mai village, Chi Dao Commune, Hung Yen Province. Dong Mai village has been involved in ULAB recycling activities since 1978 (Tung, 2011).

The recycling process involved the collection of automotive batteries from outside the village, battery breaking for lead plate removal, smelting to form new lead ingots, and manually recovering and processing the resulting waste tinker and slag for re-smelting. These processes were replicated across the village with the majority of households participating in some stage of the recycling process. Consequently, the impact of the recycling activities resulted in pervasive contamination across the whole village.

Several previous studies have described the contamination in Dong Mai (Daniell et al., 2015; Noguchi et al., 2014; Tung, 2011). A 2006 National Institute of Occupational and Environmental Health (NIOEH) study found elevated lead concentrations in air, wastewater and soil (Tung, 2011). A separate effort by a Japanese research team in 2011 found severely elevated blood and urine lead levels due to occupational exposure in adults. The study evaluated 93 individuals, including 23 children, and found an average BLL of 34 μg/dL (Noguchi et al., 2014).

The most comprehensive study of exposures to date was completed by a joint effort of the NIOEH and the University of Washington School of Public Health (USA) (referred to hereafter as 'the University of Washington'). In these assessments, lead in surface soil and dust in 11 different homes along with capillary blood samples of 109 children (age 0–10 years) were evaluated. The results revealed BLLs ranged between 12– > 65 μg/dL (the detection limit of the LeadCare® II analytical equipment) and extensive soil contamination with two-thirds of samples above the USEPA reference level for bare soil in children's play are as of 400 mg/kg (Daniell et al., 2015; EPA, 2015). For context, the equivalent Vietnamese standard is 70 mg/kg (Vietnam, 2015). Of the 109 children evaluated 33% had BLLs of 10–29.9 μg/dL; 37% 30–44.9 μg/dL; 16% 45–64.9 μg/dL, and 14% > 65 μg/dL (Daniell et al., 2015).

Following the 2006 NIOEH study (Tung, 2011) the People's Committee of Hung Yen province established an industrial park for Chi Dao Commune to consolidate ULAB recycling activities and extricate the activity from Dong Mai village. The new industrial park covered 200,000 m^2 and was located about 1 km south of the village's residential areas. Subsequently, from around 2012, the majority of ULAB industrial activity was relocated to the industrial area, although a minority continued recycling activities in the village. About 66,000 m^2 of the new industrial park is currently in use.

In 2012, Pure Earth, an international non-profit organization dedicated to solving pollution problems in low- and middle-income countries where human health is at risk, became aware of the site through its Toxic Sites Identification Program (Ericson et al., 2013). From 2013–2015 Pure Earth worked jointly with the Vietnamese Centre for Environment and Community Development (referred to hereafter as 'CECoD') to assess the extent and severity of contamination and execute a targeted intervention. The intervention was supported by national and international organizations: the Centre for Environmental Consultancy and Technology of the Vietnam Environment Administration (referred to hereafter as the 'Environmental Administration') (Hanoi, Vietnam), the International Lead Management Centre (Research Triangle Park, USA), the University of Washington, and local community and industry partners. This study details the intervention and assesses its efficacy and potential for wider application in similarly impacted LMICs, particularly where financial resources are limited.

Assessment of the key sources of lead exposure in Dong Mai included contaminated indoor dust and soils in outdoor residential and public spaces. Soil has long been identified as a significant pathway of lead exposure (Mielke and Reagan, 1998). Children in particular ingest high levels of dust from soil and soil itself (Abrahams, 2002; Stanek and Calabrese, 1995).

At the study site, a primary source of contamination was identified as legacy waste from previous recycling activities, which because of its scale had resulted in exposures across the village. In addition to the legacy waste sources, ongoing recycling activities were also identified as a secondary source of contemporary contamination. These recyclers were engaged in manual tinker separation, battery breaking and smelter operations. Lead dust contained on all worker's clothing was also an important source of exposure to the workers and their families (Daniell, 2015). A further source of contamination involved the loss of primary lead material during its transport through the village on motorbikes and small trucks to the formal industrial area for processing.

2. Materials and methods

The approach employed in Dong Mai involved a series of increasingly detailed environmental assessments to guide targeted interventions. Environmental and human exposure monitoring were used to assess their efficacy.

2.1. Environmental assessment

Assessments of environmental contamination were carried out on an ongoing basis, beginning in December 2012 with a rapid qualitative assessment of contamination sources and exposure pathways by CECoD investigators. The rapid assessment confirmed earlier reports of poor work practices including breaking and open smelting of batteries in residential areas, lack of personal protective equipment and the storage and transport of hazardous material in the village.

A detailed assessment of the extent of soil contamination was conducted by Pure Earth in May 2013. In situ surface soil lead measurements at 235 sites were completed over two days in residential areas and public spaces using a handheld portable InnovX Delta series X-ray fluorescence instrument (pXRF) with a lower detection limit for lead of 5 mg/kg. The instrument was calibrated twice daily with a 316 steel clip provided by the manufacturer. Following calibration, certified reference materials produced by the National Institute of Standards and Technology (2702: Inorganics in Marine Sediment) were used to confirm the accuracy of lead detection (Gonzalez et al., 2016). In situ pXRF analysis has been shown to be consistent with more commonly used wet chemistry techniques (e.g. Inductively Coupled Plasma Atomic Emission Spectrometry and Inductively Coupled Plasma Mass Spectrometry), particularly in the context of high density sampling like that carried out here (Rouillon et al., 2017; Rouillon and Taylor, 2016). Water samples were not collected by the assessment team as previous data indicated this lead exposure pathway was low risk (Anh, 2008).

From September 2013 to February 2014 the Environmental Administration conducted a qualitative assessment of every village residential yard (n = 546). At that time 269 households were identified

متن کامل مقاله ← دریافت فوری

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات