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E-Waste Informal Recycling: An Emerging Source of Lead Exposure in South America

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Abstract

BACKGROUND—Primitive electronic waste (e-waste) recycling creates exposures to several hazardous substances including lead. In Uruguay, primitive recycling procedures are a significant source of lead exposure.

OBJECTIVES—The aim of this study was to examine lead exposure in blood lead levels (BLLs) in low-income children exposed to lead through burning cables.

METHODS—A sample of children and adolescents exposed to lead through burning cable activities were assessed at the Department of Toxicology in Montevideo, Uruguay, between 2010 and 2014. Soil lead levels of residences were taken shortly after their assessment.

FINDINGS—The final sample included 69 children and adolescents (mean age 7.89 years). More than 66% of participants had an additional source of lead exposure—manual gathering of metals—and <5% were exposed to lead through landfills or paint. Average BLLs at first consultation were 9.19 ug/dL and lower at the second measurement (5.86 µg/dL). Data from soil lead levels ranged from 650 to 19,000 mg of lead/kg of soil. The interventions conducted after the assessment included family education in the clinic and at home, indoor and outdoor remediation. We found a decrease in BLLs of 6.96 µg/dL. Older children had lower BLLs ($r = -0.24$; $P = 0.05$). Statistical analyses also showed that children living in areas with higher soil lead levels had significantly higher BLLs ($r = 0.50$; $P < 0.01$). Additionally, we found greater BLLs from burning cable activities when children had been exposed to lead-based paint ($r = 0.23$; $P < 0.1$).

CONCLUSION—Among children exposed to e-waste recycling, the most common additional source of lead exposure was the manual gathering of metals. The average BLL among children and adolescents in this study is higher than the BLLs currently suggested in medical intervention. Future research should focus on exploring effective interventions to reduce lead exposure among this vulnerable group.

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Keywords

e-waste; lead exposure; children

INTRODUCTION

Primitive electronic waste (e-waste) recycling is a source of exposure to several hazardous substances including lead,[1,2] contributing to the elevation of blood lead levels (BLLs) in children living in the surrounding environment.[3,4] In Latin America, Chile (9.9 kg per individual) and Uruguay (9.5 kg per individual) generate the highest amount of waste from electronic products per capita.[5] In Uruguay, primitive recycling procedures through open cable burning to obtain copper has been a significant source of lead exposure for more than decade.[6] Among children, the sources of lead exposure include burning activities, manual dismantling of electronic products, and living near recycling-contaminated sites.[7] Exposure to lead among children occurs primarily in areas of greater social and economic vulnerability, in which families work without workplace protections. Recycling electronic products and other informal activities that require direct contact with electronics and hazardous electronic waste represent the largest source of family financial support for economically disadvantaged families.[5,7]

The aim of the present study was to examine lead exposure among children in low-income families and therefore analyze the BLLs of children exposed to lead through burning cable activities; compare additional sources of lead exposure; and analyze lead soil levels in the families' residences. We also analyzed differences of BLLs in this sample after conducting interventions to decrease the continued risk for lead exposure.

METHODS

A sample of children and adolescents exposed to lead through burning cable activities were assessed at the Environmental Pediatric Unit of the Department of Toxicology (University of the Republic) in Montevideo, Uruguay, between November 2010 and July 2014. Participants were recruited using different strategies. First, adolescents were identified through medical records from the Department of Toxicology if they had previously been exposed to lead or if they had been previously studied for lead exposure. The parents of potential participants were telephoned by doctors from the Pediatric Environmental Unit and asked if they were interested in participating in a study in which their children's blood would be tested for lead. Parents were told that they and their children would be asked to answer several questions regarding their health and work habits (if any), that blood would be drawn, and that the children would receive a physical examination by a physician. For parents who were interested in participating, clinic staff obtained consent and child assent before enrolling children in the study.

The second recruitment strategy included identifying children who had been referred from primary care clinics under suspected lead exposure or recruited when parents spontaneously and voluntarily had a consultation at the Pediatric Environmental Unit. At the time of enrollment, clinic staff performed a standardized interview of one parent (either the mother or father). Blood was collected from the participants at the time of interview at the Pediatric Environmental Unit and was analyzed at the Laboratory of the Department of Toxicology and Environmental Hygiene of the School of Chemistry of the University of the Republic in Montevideo where BLLs were determined using flame atomic absorption spectrophotometry. Additional data were taken from patient medical records. A second measurement of BLLs was included for children who were <6 years old and who had <1 year between both measurements.

Additionally, soil lead levels of the family's residence were taken shortly after their consultation at the health care center and were processed and analyzed by professionals of the Environmental Control and Quality Assessment Service from the Montevideo City Council, using flame atomic absorption spectrophotometry.[8] The work group considered the US Environmental Protection Agency (EPA) residential hazard standard of 400 mg/kg of soil.[9]

For the present study, descriptive statistical analyses were conducted for all study variables and group comparisons were tested by carrying out *t* tests and pair-wise correlations for the relevant variables.

RESULTS

The final sample included 69 children and adolescents (Table 1) ranging in age from 1 month to 17 years, and mean age 7.89 years (SD = 4.60). Slightly more than half of the sample (53.6%) was female. More than 90% lived in Montevideo (capital of Uruguay). Burning cables was the sole source of lead exposure in 28.9% of the sample. More than 66% of children and adolescents studied had an additional source of lead exposure: gathering of metals (63.8%), landfills (2.9%), and paint (4.4%). Burning cables within the home was reported by almost half of the sample (49.3%) and was reported as a source of child labor in 5 patients (7.3% of the sample). BLLs at the first consultation (referred as the first measurement) ranged from 0.3 to 28.4 μg/dL with a mean of 9.19 μg/dL, whereas BLLs at the second measurement during the first year of the initial consultation (available for 10 children age <6 years) ranged from 0 to 19 μg/dL with a mean of 5.86 μg/dL. The mean BLLs of individuals exposed to lead solely through burning cables activities (n = 20) was 8.23 μg/dL. Data from soil lead levels were obtained for 40 participants. For this group, lead levels ranged from 650 to 19,000 mg/kg of soil, with a mean of 7103.48 mg/kg. The type of interventions conducted after the first consultation included family education in the clinic (100%), family education at home (75.3%), indoor remediation (11.6%), outdoor remediation (10.1%), relocation of the family to an unleaded environment (2.9%), and suggestions to increase the time spent outside the home (2.9%). Comparing the first and second measurements, we found a decrease in BLLs that ranged from 1.5 to 14.1 μg/dL (mean BLL change, −6.96 μg/dL).

Results are available in Table 2. We observed a decreasing association in BLLs among older children ($r = -0.24$; $P = 0.05$). Statistical analyses also showed that children living in areas with higher soil lead levels had significantly higher BLLs ($r = 0.50$; $P < 0.01$). Additionally, we found greater BLLs when burning cable activities were associated with paint as another source of lead exposure ($r = 0.23$; $P < 0.1$).

DISCUSSION

The aim of this study was to describe the BLLs of children exposed to lead during the process of e-waste recycling in Montevideo, Uruguay. The majority of patients in this study were recruited from Montevideo, the capital city, where half of the country's population resides and where more than half of the burning cable activities occur. Results from international studies have similarly revealed that BLLs are significantly higher among children exposed to e-waste recycling living in urban environments than those living in rurally.[10]

Among children who were exposed to e-waste recycling through burning cable activities, the most common additional source of lead exposure was the manual gathering of metals. This is consistent with previous national surveys revealing that the activity of working directly with metals is a common source of income for economically disadvantaged families.[11] The manual gathering of metals, however, puts the health of families, and children in particular, at great risk.

The average BLL among children and adolescents in the first assessment in the present study (9.19 µg/dL) was similar to what was previously reported in national studies.[11–13] However, the average BLL in this study was higher than the currently recommended level, suggesting the need for medical intervention (5 µg/dL).[14,15]

In this study, the highest lead levels were found among the youngest children. This finding may be due to the fact that the lead exposure is occurring at the ground level where the cables are burned and where children often play. Previous studies have been carried out with children who have had direct contact with recycling e-waste.[10,16] This study showed an indirect exposure. The finding that lead levels decrease over childhood and into adolescence is also consistent with previous reports of lead exposure.[17–19] During childhood, there is a greater chance that lead exposure results from direct hand-to-mouth contact or through breathing in the smoke of open burning activities. Furthermore, soil lead levels were above the EPA action level of 400 mg/kg and our finding that a significant association exists between higher BLLs and high soil lead levels supports the fact that children have had an indirect environmental exposure.

Additionally, the manual gathering of metals was the most commonly reported additional form of lead exposure; however, there was no significant association between this form of exposure and high BLLs. Although additional exposure to lead in paint was found only among 4.4% of the sample, this was found to be significantly associated with increases in BLLs. This finding may be a result of young children's behaviors that may put them at a higher risk than other age groups (ie, pica, onychophagia).[11,17–19]

Educational methods are an essential form of intervention of the Pediatric Environmental Unit. In the clinic, the interventions consist of educating patients and their families about proper hygiene and proper nutritional habits. Additionally, education on proper environmental hygiene is provided. Education was provided within the home for all children or adolescents who had BLLs ≥10 µg/dL, which is the level suggested by the Ministry of Public Health.[15] Unfortunately, it was cost-prohibitive to perform indoor and outdoor remediation in some cases.

Finally, we were able to obtain assessments of BLL changes (difference between the first and second assessment) for only 10 patients. Although the small number of participants limited our ability to assess the efficacy of the interventions that were carried out, the educational intervention was carried out for all of the cases where reductions in BLLs were observed, as well as remediation within the home in 2 of these cases. Within-home intervention allows the identification of the source of lead exposure, as well as contact with local public health professionals.

CONCLUSIONS

Future studies should quantify the impact of environmental interventions on reducing lead levels throughout childhood and into adolescence.

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Table 1

Demographic data and results

Variables	Percentage, %	Mean (SD)
Sex (% Female)	53.6	
Age		7.89 (4.6)
Region		
Capital	94.2	
Interior	5.8	
Lead exposure sources		
Burning cables only	28.9	
Additional lead exposure sources		
Landfills	2.9	
Gathering of metals	63.8	
Paint	4.4	
Burning cable activity		
Within the home	49.3	
Child labor involvement	7.3	
BLLs first measurement (μg/dL)		9.19 (7.14)
BLLs second measurement (μg/dL) *		5.86 (7.15)
Change in Pb (μg/dL)		−6.96 (4.6)
Interventions		
Education in the clinic	100	
Education at home	75.3	
Indoor remediation	11.6	
Outdoor remediation	10.1	
Move family	2.9	
Increase time spent outside the home	2.9	

BLL, blood lead level; Pb, lead.

*Available only for 10 individuals.

Table 2

Pearson Correlations between Study Variables and BLLs (First Measurement)

	Pb at intake	Significance	*P* value
Age	−0.24	*	0.05
Sex	0.10	ns	0.402
Burning cables only	−0.08	ns	0.48
Burning cables and landfills	0.00	ns	0.98
Burning cables and gathering of metals	−0.02	ns	0.89
Burning cables and paint	0.23	*	0.06
Soil lead levels (mg/kg)†	0.50	‡	0.0009

BLL, blood lead level; ns, not significant; Pb, lead.

* $P < 0.1$.

† Available for only 40 individuals.

‡ $P < 0.01$.