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Review

Children with health impairments by heavy metals in an e-waste recycling area

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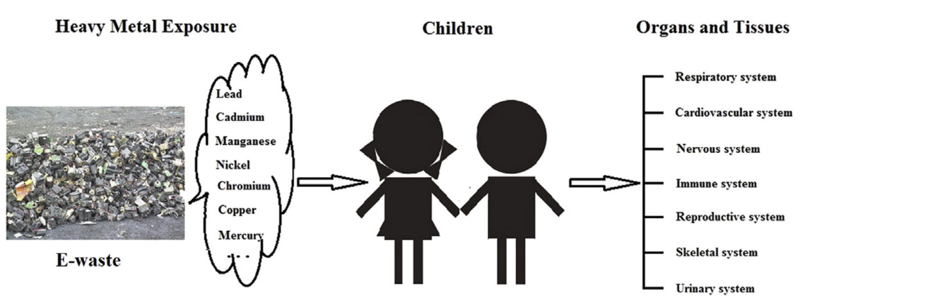
HIGHLIGHTS

- Heavy metal levels in children from Guiyu are summarized.
- Exposure pathways of the heavy metal derived from e-waste are narrated.
- Adverse effects of heavy metals on the children's health are reviewed.

GRAPHICAL ABSTRACT



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ABSTRACT

E-waste recycling has become a global environmental health issue. Pernicious chemicals escape into the environment due to informal and nonstandard e-waste recycling activities involving manual dismantling, open burning to recover heavy metals and open dumping of residual fractions. Heavy metals derived from electronic waste (e-waste), such as, lead (Pb), cadmium (Cd), chromium (Cr), manganese (Mn), nickel (Ni), mercury (Hg), arsenic (As), copper (Cu), zinc (Zn), aluminum (Al) and cobalt (Co), differ in their chemical composition, reaction properties, distribution, metabolism, excretion and biological transmission. Our previous studies showed that heavy metal exposure have adverse effects on children's health including lower birth weight, lower anogenital distance, lower Apgar scores, lower current weight, lower lung function, lower hepatitis B surface antibody levels, higher prevalence of attention-deficit/hyperactivity disorder, and higher DNA and chromosome damage. Heavy metals influence a number of diverse systems and organs, resulting in both acute and chronic effects on children's health, ranging from minor upper respiratory irritation to chronic respiratory, cardiovascular, nervous, urinary and reproductive disease, as well as aggravation of pre-existing symptoms and disease. These effects of heavy metals on children's health are briefly discussed.

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1. Introduction

Electronic waste (e-waste), such as waste laptop, and desktop computers, monitors, cell phones, keyboards, printers, copiers, televisions, refrigerators, and washing machines, are the endpoint of the vast amounts of electronic items in modern society. It was estimated that global e-waste generation was 41.8 million tonnes in 2014 and may increase to 65.4 million tonnes by 2017 (Breivik et al., 2014; Heacock et al., 2015). Ewaste contains heavy metals that can be released during inappropriate recycling processes and disposal, resulting in harming humans, animals, vegetation or other environmental materials (Luo et al., 2011; Tsydenova and Bengtsson, 2011; Xue et al., 2012; Xu et al., 2014). The countries most affected by informal e-recycling are China (Guiyu and Taizhou), India (Bengaluru and Delhi) and some African countries (Lagos in Nigeria, Accra in Ghana), where e-waste has been recycled or disposed with little or no regulation, using less advanced technology (Widmer et al., 2005; Ramesh et al., 2007; Leung et al., 2008; Chen et al., 2011; Zhang et al., 2012a). Humans can become exposed to heavy metals in air, soil, dust, water, and food sources through several routes that include ingestion, inhalation, and dermal absorption from combustion, discharges and manufacturing facilities (Kampa and Castanas, 2008; Robinson, 2009). Heavy metals cannot be degraded into less hazardous end products, which is different from organic pollutants with biodegradable capability. Although segmental heavy metals such as trace elements are essential to maintain normal metabolism to a small extent, most of heavy metals have a potentially adverse effect on human health when their concentrations are exceeded the tolerance levels due to the bio-accumulation of e-waste components and by-products in living organisms over time (Järup, 2003).

Children are considered more susceptible to hazardous metal substances compared to adults for several reasons: an excess routes of exposure (breastfeeding, placental exposures, hand-to-mouth, object-to-mouth activities); children have higher basal metabolic rate compare to adults, and they have higher comparative uptakes of food and lower toxin elimination rates; children have higher ventilation per minute in relation to body size compared to adults, and they can inhale more harmful metal substances; children have a much larger surface area in relation to body weight than adults, and they can load higher amounts of toxicants in their body through dermal absorption; their organs or tissues are developing and thus more sensitive to perturbed cellular processes; children have often higher physical activity interacted with environment compared to adults, and they are likely to receive bigger doses of toxicants, relative to their size, than adults; some exposure such as ETS and e-waste in the home is difficult to avoid for children (de Garbino, 2004). In addition, children from Guiyu are forced to exposure to the full of e-waste pollution of the environment from home, school, and play areas located near landfills and e-recycling business. It is worth mentioning that the children of e-waste recycling workers also confront take-home contamination from their parents' clothes and persons, and in particular from firsthand high-level exposure if recycling are performed in their homes. One study investigated the levels of heavy metals in workers and local adult residents in Taizhou (an e-waste exposed area in Zhejiang province, China). This study showed that the blood lead levels of workers and local adult residents were 15.1 and 8.4 μg/dL, respectively (Zhang et al., 2012b). One of our previous study reported that the blood lead level of children in Guiyu (an e-waste exposed area in Guangdong province, China) was 7.3 μg/dL (Yang et al., 2013). According to these two study results, adults seem to be more exposure to the e-waste pollution, but there is little difference in e-waste exposure between children and adults. The truth is not to be ignored that children are more easily damaged than adults when confronting even the same levels of environmental pollution because their immature systems are unable to handle and excrete some toxic materials efficiently, and their poor self-protection sense and ability againsting environmental pollution make them hard to avoid damage resulted from e-waste pollution.

Guiyu, has a 30-year e-waste dismantling history, is one of the largest e-waste destinations and recycling areas in the world. Nearly 60–80% of families in Guiyu have engaged in e-waste recycling operations run by small scale family workshops (Huo et al., 2007). About 60 chemical elements can be found in e-waste, including lead, cadmium, chromium, manganese, nickel, mercury, copper, arsenic, zinc, iron, and aluminum, many of which are potentially, or known to be, hazardous (Grant et al., 2013; Heacock et al., 2015). These metals are used in products such as circuit boards, semi-conductor chips, cathode ray tubes, coatings, and batteries (Chen et al., 2011). E-waste-derived heavy metal pollution is mainly from several e-waste recycling activities including roasting, burning, acid leaching, inappropriate shredding and dismantling (Xu et al., 2015). Informal and hazardous e-waste recycling activities caused local environmental pollution which poses a threat to human health of local residents, particularly in children (Fig. 1). Heavy metal pollution above the permissible limits has been found in children from Guiyu according to our previous