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Review

A review on human health consequences of metals exposure to e-waste in China

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ABSTRACT

As the world's the largest dumping ground for e-waste, much of the population in China is exposed to heavy metals due to informal e-waste recycling processes. We reviewed recent studies on body burdens and human health effects of heavy metals from the major e-waste recycling sites in China. The results showed that the residents in the e-waste recycling sites are facing a potential higher daily intake of heavy metals. Moreover, heavy metals had entered subjects' bodies (the collected 5 tissue samples). Additionally, individual exposure to heavy metals in e-waste has also caused negative health outcomes, especially in neonates and children. We also recorded plausible outcomes associated with exposure to e-wast (to heavy metals). A precautionary approach toward exposure, especially in neonates and children, therefore seems warranted.

1. Introduction

With the development of the electronic industry and information technology, a large amount of waste electric and electronic equipment (e-waste) (20–50 million tons per year) is being continually generated worldwide, and has become a serious problem of environmental protection as well as a risk to human health (Duan et al., 2009; Wang et al., 2013). E-waste is a crisis not only of quantity but also of toxic components, such as lead, chromium, cadmium, etc. China, as the world's leading manufacturing country, has become the largest dumping ground for e-waste (Chi et al., 2011; Song et al., 2012a, 2012c, 2013).

Much e-waste recycling in China is a conglomeration of processes carried out in the informal sector (Chan and Wong, 2013; Chen et al., 2009), by a range of legal and publicly accepted, although unregistered, businesses, who give little concern to illegal or clandestinely executed processes that can generate consequences harmful to both the environment and human health. Such processes include applying crude methods to separate substances or material of interest from their original location within the electrical/electronic equipment (Leung et al., 2007; Leung et al., 2013). The operations commonly used in processing e-waste in order to extract precious metals, such as strong acid leaching and the open burning of dismantled components, have led to the release of large quantities of toxic metals and organic pollutants into the surrounding environment (Bi et al., 2010; Birloaga et al., 2013; Fu et al., 2011; Grant et al., 2013; Gullett et al., 2007; Hischier et al., 2005; Leung et al., 2008, 2011; Wong et al., 2007).

E-waste recycling in China, especially informal e-waste recycling, has clearly become a major source of toxic heavy metals (Luo et al., 2011; Tang et al., 2010; Wong et al., 2007). Heavy metals are widely used in the manufacturing of a variety of electronic products, such as lead and cadmium in circuit boards, cadmium in computer batteries, and copper in electrical wiring (Achillas et al., 2013; Song et al., 2012b; Stevels et al., 2013; Zeng and Li, 2013; Zeng et al., 2014). It is well known that heavy metals persist in the environment and lead to poisoning at low concentrations through bioaccumulation in plants and animals or bioconcentration in the food chain (Fu et al., 2008; Luo et al., 2011; Zhang and Hang, 2009). Heavy metals can be absorbed by plants through uptake from the soil, and by animals and humans through food, water, air, soil/dust ingestion and skin contact (Li et al., 2011b; Zhao et al., 2010). Some heavy metals can become more concentrated when people ingest meat, which is higher on the food chain. In humans, lead interferes with behavior and learning abilities; copper results in liver damage; and chronic exposure to cadmium increases the risk of lung cancer and kidney damage (Balakrishnan Ramesh et al., 2007; Bhutta et al., 2011; Chan and Wong, 2013; Esteban-Vasallo et al., 2012; Grant et al., 2013; Yan et al., 2013). Children are particularly susceptible to heavy metal exposure due

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to high gastrointestinal uptake and the permeable blood–brain barrier.

Although many studies have investigated and discussed the environmental pollution of heavy metals from e-waste recycling in China, to the best of our knowledge, no systematic reviews specifically focused on body burdens, and human health effects of heavy metals have been performed. Considering the above-mentioned situation, this study reviews the current state of knowledge on heavy metal human exposure to heavy metals from e-waste in China, with almost all the representative data now available on exposure sources, human tissue markers, and human health in China. The main objectives of this study were to provide comprehensive information on the current human health effects of heavy metals and to assess the evidence for the association between such heavy metals exposure and the human body burden (or human health) in China. Fig. 1 presents the e-waste exposure areas and the control areas referred to in this paper. As shown in Fig. 1, most studies mainly focused on the southeast region of China, because e-waste recycling processed in China (especially the informal sectors) is mainly limited to those regions, e.g. Guiyu, Taizhou, and Qingyuan.

2. Review methods

We systematically searched the electronic databases (Web of Knowledge, Science Direct, Google Scholar, CNKI (database of Chinese journal)) for the search terms (e-waste, electronic waste, WEEE, heavy metals, body burden, health, and exposure) from Jun 1 2013 to Sep 2014. Of the 31 full-text articles assessed for eligibility, we excluded the studies reporting results in reviews, letters to the editor, and abstracts, and those that did not report an outcome related to heavy metal effects from e-waste, resulting in these published studies that met the searching criteria. To focus our study, we did not consider exposure to other pollutants (PBDEs, PCBs, and PCDD/Fs) or studies in other countries (such as India and African nations). Our search was not restricted to the English language, nor by any other means. Relevant articles published in languages other than English, especially Chinese, were translated. A data extraction sheet was pilot tested and revised to include: publication details, study characteristics (period, location, and sampling size), exposure and outcome measures, and study outcome.

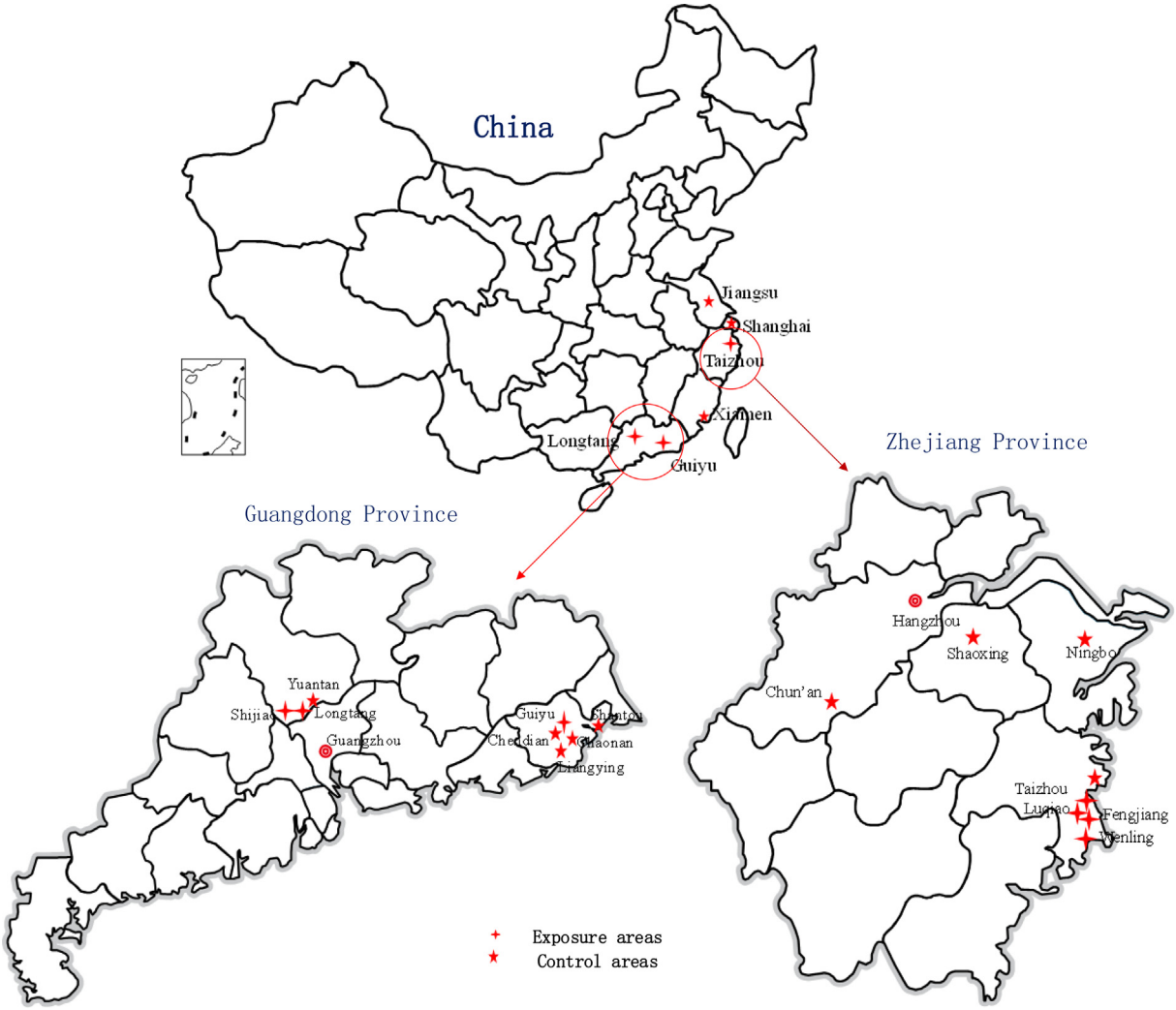

Fig. 1. E-waste exposure and control areas referenced, in China.