Invited paper

Health hazards of child labor in the leather products and surgical instrument manufacturing industries of Sialkot, Pakistan

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Abstract

Child labor is a major challenge in the developing countries and comprehensive health hazard identification studies on this issue are still lacking. Therefore, the current study is an effort to highlight the health concerns of child labor exposed in the key small scale industries of Sialkot, Pakistan. Our findings revealed jolting levels of heavy metals in the urine, blood, serum, saliva, and hair samples collected from the exposed children. For example, in the urine samples, Cd, Cr, Ni, and Pb were measured at the respective concentrations of 39.17, 62.02, 11.94 and 10.53 mg/L in the surgical industries, and 2.10, 4.41, 1.04 and 5.35 mg/L in the leather industries. In addition, source apportionment revealed polishing, cutting, and welding sections in the surgical industries and surface coating, crusting, and stitching sections in the leather industries were the highest contributors of heavy metals in the bio-matrices of the exposed children, implying the dusty, unhygienic, and unhealthy indoor working conditions. Further, among all the bio-matrices, the hair samples expressed the highest bioaccumulation factor for heavy metals. In accordance with the heavy metal levels reported in the exposed children, higher oxidative stress was found in the children working in the surgical industries than those from the leather industries. Moreover, among heavy metals’ exposure pathways, inhalation of industrial dust was identified as the primary route of exposure followed by the ingestion and dermal contact. Consequently, chemical daily intake (CDI), carcinogenic and non-carcinogenic hazard quotients (HQs) of heavy metals were also reported higher in the exposed children and were also alarmingly higher than the corresponding US EPA threshold limits. Taken all together, children were facing serious health implications in these industries and need immediate protective measures to remediate the current situation.

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1. Introduction

Globally, 246 million children (age 5–18 years) are engaged in different occupational settings, and 85 million among them belong to the hazardous occupations mainly in the developing countries, which encounters their basic rights of health, safety, and moral development (ILO, 2015). In South Asia, 16.7 million children are accounted for the child labor with 3.4 million in Pakistan, where 41% occupational settings are declared as hazardous (ILO, 2015). Estimates showed that about 5800 children and 30,000 adults are working respectively in the surgical and leather industries of Sialkot, Pakistan (ILO, 2004). However, the baseline data of child labor working in the leather industries is absent. Previously, the surgical and leather industries were listed under the category of hazardous occupations by the Convention 182 of the International Labor Organization (ILO) because 72% of the children working in these industries were observed with work related illness or injuries (ILO, 2011). Published reports have mentioned heavy metal associated oxidative stress, DNA damage, and impairment of hepatic, hematological and renal functions in the adult and child workers in these industries (Khan et al., 2013; Sughis et al., 2012). However, comprehensive studies are still scarce, which highlight the health hazards of heavy metals to the child labor via assessing multiple biomarkers, oxidative stress, bioaccumulation and carcinogenic
health risks associated with the industrial dust exposure.

The surgical and leather industries of Sialkot have drawn world's attention in the last decade, being the primary manufacturers of related products in Asia (Bhatta, 2006). Previous reports have highlighted the worse working conditions in these industries, albeit only a few scientific studies are available those focused on occupational health assessment associated with the heavy metals exposure in the workers (Junaid et al., 2016a; Khan et al., 2013) and rarely in the child labor (Sughis et al., 2014). Generally, prolonged occupational exposure to heavy metals can induce different health hazards such as asthma, hypotension, gastrointestinal diseases, renal and hepatic failure and even cancer, and children are more prone to such health impacts (ATSDR, 2000; Jimenez-Rodriguez et al., 2009; Jomova and Valko, 2011). Previously, heavy metals e.g. Cr, Ni, Pb, Cd and Cu were extensively studied due to their environmental persistence, ubiquitous nature, general and occupational exposure risks, innate toxicity and carcinogenic behavior (Burgos et al., 2017; Fraga, 2005; Gil et al., 2011; Vimercati et al., 2016).

In general or occupational biomonitoring, urine and blood samples are widely used bio-matrices (Table S1). However, recent studies have highlighted the benefits of using the non-invasive biomatrices (hairs and saliva) and limitation of mere relying on the classical bio-matrices (urine and blood) for the purpose of exposure assessment (Gil et al., 2011; Mohmand et al., 2015). For example, urine and blood samples only reflect the recent exposures, therefore, using them to measure the chronic exposures can lead towards biased assessment (Gil et al., 2011). Further, hair samples can reflect the past exposure (up to 1 year) and also have higher bio-accumulation potential of heavy metals due to their slower growth rate (10 mm per month) and metal bonding properties (Gil et al., 2011). In addition, hairs and saliva samples are easily accessible and stable matrix, which make sample collection, storage, and transportation easier (Pereira et al., 2004). However, these matrices have several drawbacks, e.g. the natural variation of heavy metal concentrations in hair samples due to the different levels of external contamination based on washing methods, age, gender and personal habits of the sampled population (Pereira et al., 2004). Further, the heavy metal levels reported in hair samples revealed almost negligible correlation with those measured in other biomatrices and the existing literature is also insufficient to understand the kinetics of heavy metals in non-invasive biomatrices (Pereira et al., 2004). For saliva as biomonitoring matrix also has several limitations such as variations in flow rate, lack of the standard reference material, low metal content, and the possibility of the blood contamination (Gil et al., 2011). These flaws make non-invasive biomatrices a secondary choice with limited acceptance among the scientific community. Although researchers have mixed opinions about their use for biomonitoring purpose, we considered them as the mandatory biomonitoring tools to reduce the biases and evaluate contamination status of the child labor via a holistic approach.

Recently, the indoor dust has proven as an excellent matrix to measure the health risks of exposed individuals (Kurt-Karakus, 2012; Mohmand et al., 2015). The human body can expose to the dust particles via different routes: inhalation, ingestion and dermal contact (Hu et al., 2012). In the leather industries, fine dust particles (<10 μm) to fibers (30–1200 μm) (IARC, 2012) and in the surgical industries ultra-fine dust particles (<100 nm) are generated (Makinen and Linnaimmaa, 2004). The dust produced from tanning of leather contains 0.1–4.5% of Cr (III) (IARC, 2012) and dust particles emitted from polishing of the steel products contain 12.5 and 0.19% of Cr and Ni, respectively (Sughis et al., 2012). Moreover, the welding of steel generates aerosols, those encompass significant quantities of Cr, Mn, and Ni (Miettinen et al., 2016). The molding of steel in arc furnace also produces dust that contains Pb and Zn (Rodgers et al., 2015). International Agency for Research on Cancer (IARC) have listed wastes from leather and steel industries as human carcinogens, and several studies have highlighted the incidences of the nasal, paranasal sinuses, blood, lung, stomach, respiratory tract, colon, rectum and bladder cancers in exposed workers (IARC, 2012) (Cross et al., 1999). Previous studies only evaluated the health risks of the dust in non-industrial settings, but this is the first robust study to evaluate the health risks (carcinogenic and non-carcinogenic) of industrial dust exposure. Moreover, this study provides the detail insights about the heavy metal levels, associated oxidative stress, bioaccumulation, potential sources, and exposure tendencies (recent or long-term exposure) of children in the surgical and leather products manufacturing industries of district Sialkot, Pakistan.

2. Materials and methods

2.1. Study area

The Sialkot city is situated between 32°29′33.65″N Latitude and 74°31′52.82″E Longitude. The city is well-known all over the world for its sports goods, surgical instruments, leather products, processed food, and ceramic industries (Qadir et al., 2008), therefore, unplanned industrial growth and poor management of hazardous wastes are causing serious threats to the natural resources of the city (Malik et al., 2010; Ullah et al., 2008). Ten random potential industries were selected for the sampling of the bio-matrices and indoor dust. The map of the study area is presented in Fig. 1, which denotes the surgical industries as S1, S2, S3, S4, and S5, and the leather industries as T1, T2, T3, T4, and T5. Most of the surgical industries were located inside the urban area, and children are additionally exposed to the atmospheric pollution, while the leather industries are located on the city outskirts. The effluents from most of these industries drained to nullahs (Palkhu, Bhed, and Aik) in the city, which ultimately inflow to the Chenab River (Fig. 1).

2.2. Study group

A total of 60 healthy children were recruited voluntarily from 10 industries (five surgical and five leather industries, 6 children/unit), with age varying from 8 to 18 years for the collection of blood, serum, urine, saliva, and hair samples. All of the biological matrices were collected from each child. Additionally, a total of 15 healthy children (unexposed control group) were voluntarily recruited to collect the same set of samples for comparison. The control samples were taken from the unexposed population of Cantonment area, Sialkot with hygienic indoor and outdoor environment. The control participants were school going children and unexposed to the indoor industrial activities. However, they generally exposed to the heavy metal sources (food, bare soil and atmospheric pollution etc.) other than industries during their normal outdoor activities. All of the participants were examined before sampling; unhealthy workers with diseases or bleeding in the mouth were not recruited; physically and psychologically stable workers were selected voluntarily for sampling. Further details about sample collection, storage, pretreatment, and digestion are given in Appendix 1 (Text S1-S3).

2.3. Ethical statement

All the ethical and legal standards related to this study were approved by Ethical Committee, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad and all of the experiments fulfilled the mandatory requirements of international regulations.
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