Science of the Total Environment 633 (2018) 293–299

Contents lists available at ScienceDirect

Science of the Total Environment

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

Assessment of lead exposure among automobile technicians in Khyber Pakhtunkhwa, Pakistan☆

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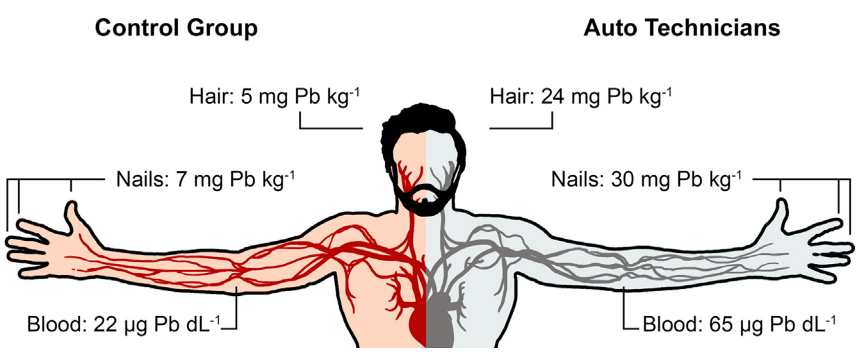
HIGHLIGHTS

- Workers in automobile repair shops in 5 cities in Pakistan have elevated levels of lead in blood, hair, and nails.
- The blood lead levels (BLL) for more than half of the workers exceed 50 μg dL^{-1} and require intervention.
- Specific task performed by the workers, such as painting or mechanic, did not influence the average levels of Pb exposure.
- The workers were unaware of their exposure to lead, and few repair shops offered hygiene for prevention of contamination.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 12 December 2017
Received in revised form 12 March 2018
Accepted 15 March 2018
Available online 22 March 2018

Editor: Wei Huang

Keywords:
Lead toxicity
Lead exposure
Occupational exposure
Automobile technicians
Health risk
Blood lead levels
Pakistan

ABSTRACT

Exposure to Pb among automobile technicians in selected towns of Khyber Pakhtunkhwa Province, Pakistan, was studied using a questionnaire, biological sampling (blood, hair, nails), and analysis of Pb biomonitoring data across various subgroups of occupation, age, and years of exposure. The study population included exposed automobile technicians (n = 50) and a control group (n = 50). The automobile technicians were further stratified into 4 groups: mechanics, auto-body technicians, electricians, and painters. Mean Pb levels in biological samples of the automobile technicians were significantly higher than in the control group ($P < 0.01$). The Pb concentrations (mean ± standard deviation) in whole blood, hair, and nails of automobile technicians were 65.3 ± 41.9 μg dL^{-1}, 23.6 ± 11.2 mg kg^{-1} and 29.7 ± 14.5 mg kg^{-1}, respectively, whereas concentrations in the control group were 21.7 ± 17.6 μg dL^{-1}, 4.8 ± 3.4 mg kg^{-1} and 7.2 ± 3.9 mg kg^{-1}. Fifty two percent of the automobile technicians had blood levels >50 μg dL^{-1}, but only 14% of the control group exceeded this level. Considering that Pb blood levels of 50 μg dL^{-1} exceed maximum concentrations recommended by leading public health organizations, appropriate measures should be taken to protect the welfare of the exposed automobile technicians and their families.

Abbreviations: BLL, blood lead levels; YWE, years work experience.
☆ Capsule: Automobile repair technicians in Pakistan have higher blood lead levels and higher Pb content in hair and nails than an unexposed control group and are at risk of Pb-related health issues.

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https://doi.org/10.1016/j.scitotenv.2018.03.160
0048-9697/

1. Introduction

Lead (Pb) contamination is a global health problem (CDC, 2011) particularly in developing countries like Pakistan (Keller et al., 2017). Concerns associated with Pb pollution are heightened because Pb is ubiquitous, persistent, and potentially toxic (IARC, 2006).

Lead is a crucial part of many commercial products and industrial processes (CDC, 2011) that may involve human exposure to this toxic heavy metal (Kasuba et al., 2010). Although Pb in gasoline was once a major source of Pb in the environment (Menkes and Fawcett, 1997), very few countries continue to add Pb to gasoline, and Pakistan banned its use in 2001 (Kadir et al., 2008).

Lead exposure in humans may cause acute or chronic effects ranging from alteration of crucial functions to life-threatening toxicity (CDC, 2011). The International Agency for Research on Cancer (IARC) classified inorganic Pb as a potential human carcinogen (IARC, 2006; WHO, 2011). Other Pb-induced toxicities include oxidative stress (Roy et al., 2015); cognitive deficits (Braun et al., 2012); intelligence, memory, and attention disorders (Arbuckle et al., 2016); depression, panic, anxiety (Bouchard et al., 2009.); anemia (Counter et al., 2012), central nervous system disorders (Luo et al., 2012; Mansouri and Cauli, 2009); immunotoxicity (Zhang et al., 2016); effects on fetus and child growth (Dallaire et al., 2014); cardiovascular effects (Skröder et al., 2016); and neurotoxic effects (Mason et al., 2014).

Concentrations of Pb in whole blood, hair, and nails are the most widely used biomarkers to evaluate Pb toxicity and contamination among exposed human populations (Ikegami et al., 2016; Kempson and Lombi, 2011; Koseoglu et al., 2017; Were et al., 2008). The accumulation of Pb in these tissues is a reflection of their growth rates: human hair normally grows 10 mm month^{-1} (Gil et al., 2011); nails grow from 0.9 to 1.5 mm month^{-1} (Fleckman, 1997); but, blood cells undergo complete replacement in four to six weeks (Gil et al., 2011). Due to the slow growth rate, Pb concentrations in human hair and nails reflect long-term exposure, whereas blood lead levels (BLLs) are more indicative of recent, short-term exposure (Gil et al., 2011; Slotnick and Nriagu, 2006; WHO, 2011).

Millions of people are occupationally exposed to Pb pollution (Nersesyan et al., 2016) through various pathways including dermal contact, ingestion, and inhalation (Faiz et al., 2012; Wu et al., 2015). Occupational Pb exposure is greatest for workers in lead smelters, battery manufacturing, ceramics (Kasuba et al., 2010), painters (Ogawa et al., 2008) and automobile technicians (Alli, 2015). The importance of the automobile technician pathway of exposure escalates as the number of automobiles increases (Pachathundikandi and Varghese, 2006). Worldwide, Pb exposure among automobile technicians constitutes 0.9% of the total health burden with the majority in developing countries (Saliu et al., 2015).

Blood Pb level standards and guidelines have been evolving over the past decades. Improved analytical techniques for Pb in blood and extensive studies have led to the discovery that very low BLLs can be harmful. Prior to 1978, the U.S. Occupational Safety and Health Administration (OSHA) BLL limit was 80 μg dL^{-1} (National Research Council of the National Academies, 2013). The U.S. Occupational Safety and Health Administration (OSHA) reduced the recommended BLL to 40 μg dL^{-1} in 1978. In 1999, the U.S. Center for Disease Control established a BLL "level of concern" as their benchmark, and a BLL below 10 μg dL^{-1} was considered to be safe for adults and children. At approximately the same time, the European Union Scientific Committee on Occupational Exposure Limits recommended 30 μg dL^{-1}; German Commission for the Investigation of Health hazards of Chemical Compounds in the Work Area recommended a BLL of 40 μg dL^{-1} for men and women over 45 years old and 10 μg dL^{-1} for women under 45 years old; the United Kingdom Health and Safety Executive established BLLs ranging from 10 to 50 μg dL^{-1} depending upon age and gender (National Research Council of the National Academies, 2013). "Current research continues to find that BLLs previously considered harmless can have harmful effects in adults," (CDC, 2013).

Blood lead levels have been surveyed extensively on a global basis, and many studies have been performed on adults in Pakistan (Waseem and Arshad, 2016). The lowest BLLs in unexposed populations in Pakistan were reported by Riaz et al. (2017) as 0.5 μg dL^{-1}, but others reported much higher values in healthy/control Pakistani groups: 9.6 μg dL^{-1} (Kazi et al., 2014), 11.6 μg dL^{-1} (Yakub and Iqbal, 2010), 14 μg dL^{-1} (Rahman et al., 2006), 15 μg dL^{-1} (Younas and Shahzad, 1998), and 18 μg dL^{-1} (Afridi et al., 2006).

For human hair, Pb levels of concern have not been established; however, the concentration of Pb in human hair should normally be <5 mg kg^{-1}, and concentrations above 25 mg kg^{-1} are indicative of very high exposure (Furman and Laleli, 2000). Batool et al. (2015) found hair samples in young Pakistanis to range from 5.7 to 10.1 mg Pb kg^{-1}. Kazi et al. (2014) examined Pb in new Pakistani mothers exposed to industrial pollution and in an unexposed control group; concentrations of 6.5 mg Pb kg^{-1} hair were found in the control group with 8.2 mg Pb kg^{-1} hair in the exposed group. Hair samples from steel mill workers were found to contain an average of 16 mg kg^{-1} compared to 6.8 mg kg^{-1} in a control group (Afridi et al., 2006).

Nail sampling for biomonitoring is less common, but some results are available (Waseem and Arshad, 2016). Lead concentrations in the nails of apparently healthy people ranged from 2 to 90 mg kg^{-1} (Waseem and Arshad, 2016). In studies conducted in Pakistan, concentrations in healthy subjects ranged from 12.5 to 20.1 mg kg^{-1} (Batool et al., 2015) and 13.5 to 94.0 mg kg^{-1} (Qayyum and Shah, 2014).

Automobile repair and maintenance has been identified as a high risk occupation for exposure to Pb (NIOSH, 2017; OSHA, 2013). In the Philippines, the average BLL in automobile repair technicians was 23 μg dL^{-1}, significantly higher than the 15 μg dL^{-1} found in the unexposed population (Suplido and Ong, 2000). A study in Washington State found that 26% of automobile workers who repair radiators were found to have elevated BLL of >25 μg dL^{-1} (Whitaker, 2003). A study in Rhode Island found 22% of the screened automobile repair technicians had BLL > 30 μg dL^{-1} (Enander et al., 2004). Pachathundikandi and Varghese (2006) found 8 μg dL^{-1} in the unexposed population in India and 15 μg dL^{-1} in automobile workshop workers. Subjects from Nigerian roadside and "organized" (commercial) automobile technicians were tested for BLL; 46% were found to have <25 μg dL^{-1}, but 37% had BLL > 40 μg dL^{-1} (Saliu et al., 2015). Studies of occupational exposure to Pb among adult automobile technicians in Pakistan have been scarce.

The U.S. CDC (2011) urged increased interventions for the prevention of workplace Pb exposure along with regular exposure surveillance due to health concerns. This is of particular concern in Pakistan because of the presence of workers < 18 years old with limited protection. The present study has the following objectives: 1) assess Pb concentrations in biological samples (blood, hair, nails) of automobile technicians and control group in selected towns of Khyber Pakhtunkhwa, Pakistan, 2) determine Pb exposure levels among various groups of automobile technicians, 3) evaluate the influence of factors such as age and years of experience on accumulation Pb in the biological samples.

2. Materials and methods

2.1. Ethical considerations

The research protocol for the study was approved by the Ethics Committee of the University of Peshawar, Pakistan (Approval Reference No. 3653/PhD/Adms-III; September 6, 2015) and performed according to the 1964 Declaration of Helsinki (World Medical Association, 2013). Sampling commenced in February 2016 and was completed in May 2016. Informed consent was obtained from the study population for collecting blood, hair, and nail samples and for administering the questionnaire. Individuals who were not willing to participate were excluded from the study. Blood, hair, and nail samples were collected by trained medical technicians (certified paramedics).