

Lead exposure among five distinct occupational groups: A comparative study

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Abstract: This study was conducted to evaluate blood lead concentration among five selected occupational groups. The five groups were: hospital health workers, shop workers, taxi drivers, automobiles mechanics, and wood workers. The groups did not significantly differ among each other in the average of age and work years. ANOVA test revealed significantly higher mean lead blood concentration in taxi drivers, automechanics, and wood workers compared to other groups. Additionally, workers with lead concentration >0.483 $\mu\text{mol/L}$ ($10\mu\text{g/dL}$) were more likely to have frequent muscle pain compared to those with lower concentrations. No association between other symptoms of lead exposure/toxicity and blood lead concentration was detected. In conclusion, special attention must be directed toward lead blood levels and lead poisoning symptoms when examining patients from certain occupational groups such as taxi drivers, automechanics, and wood workers. Special safety precautions and educational programs are also needed to limit the lead exposure in these occupational groups.

Keywords: Lead exposure, blood lead, occupational groups, health impact.

INTRODUCTION

Lead is a non-essential trace element for human. It has a toxic potential for biological systems. High levels of lead can have adverse effects on many systems in the body including the neurological (mental retardation, learning and behavioral abnormalities), reproductive, gastrointestinal, hematopoietic and renal systems (Nemsadze *et al.*, 2009, Rosin, 2009, Warniment *et al.*, 2010, Kordas, 2010, Chandran and Cataldo, 2010). A recent review concluded that early life exposure to lead has late-life neurodegenerative effect in old age (Basha and Reddy, 2010).

The primary source for adult exposure to lead occurs in the work place. Lead exposure sources include gasoline, paint, smelters, fuels used for heating, battery recycling factories, some glazed ceramics and some Asian cosmetics (Kirel *et al.*, 2005). The blood lead level is the best indicator of recent exposure of lead. The World Health Organization (WHO) suggests that a blood lead level of 0.965 $\mu\text{mol/L}$ is the maximum acceptable concentration. In the Eastern Mediterranean region, there are limited reports on the blood lead levels and on the occupational lead exposure. A study by Safi *et al.*, (Safi *et al.*, 2006) showed lead blood levels between 0.154 and 0.415 $\mu\text{mol/L}$ among children in the region. Using atomic absorption spectrometry, higher concentrations of lead

and other metals were detected in human teeth from Jordan (mean 1.39 $\mu\text{mol/L}$) with level variations depending on age, sex, type of teeth filling, smoking and area (Alomary *et al.*, 2006). Working or living near battery factories also has been associated with higher lead blood concentrations (Safi *et al.*, 2006, Nusier *et al.*, 2003). Higher Lead concentration in the blood was linked to certain occupations such as metal casters (2.01 $\mu\text{mol/L}$) and radiator welders (1.58 $\mu\text{mol/L}$) (Hunaiti and Soud, 2000).

This study was conducted to evaluate the lead levels among five occupational groups: hospital health workers, shop workers, taxi drivers, automechanics, and wood workers. The study also examined the possible association between lead blood levels and symptoms of lead exposure among workers.

Experimental Section

A total of 244 male volunteers of Jordanian workers were involved in this study. Five groups of workers were evaluated. These groups are: hospital health workers (doctors, nurses, lab technicians, hospital pharmacists and administrators), shop workers (street vendors, downtown shops, community pharmacists, barbers and butchers), taxi drivers (taxi driver service, bus drivers, bus servants), automechanics (battery repairers, welding, auto mechanic, car electricians, exhaust repairers, tire repairers, oil changers, radiator repairers, car painters and car glass workers) and wood workers (wood industry workers).

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The protocol of the study was approved by the institutional review board (IRB) of Jordan University of Science and Technology. Procedures carried were in accordance with the Helsinki Declaration of 1975 and its revisions. Participants' were required to sign written informed consents.

In this study, participants were randomly approached at their work places using rolling-sampling method. This study was conducted in various regions of north of Jordan, industrial Irbid city and Irbid hospitals. A questionnaire was used to collect information about demographic and occupational characteristics of participants. The questionnaire was distributed and in the presence of the researcher. Full explanation of the study and how to complete the questionnaire was provided to each of the participants. The researcher was available for any required assistance during filling of the questionnaire.

The questionnaire gathered information that included demographic data, frequency and type of symptoms that could be related to workplace lead exposure. Workers who are 18 years of age or older were allowed to complete a survey. Questionnaire is available upon request at (younisgh@just.edu.jo). After completing the questionnaire, participants were given a booklet about the risk of lead exposure and how it can be minimized.

Blood samples (5mL) were collected from each participant right after completing the questionnaire, in vacutainer EDTA-tubes and placed at -20°C until analysis. The analysis of blood samples for lead was carried out using Graphite Furnace Atomic Absorption (GFAA) technique (SOLAAR 969 AA spectrometer, UNICAM Atomic Absorption, TJA solutions) at Princess Haya Biotechnology center, in the trace elements monitoring lab at King Abdullah University Hospital, Irbid-Jordan.

All blood samples were treated under fume hood to avoid unwanted contamination with any external source of lead from the environment or dust. Steps of lead analysis were carried out as follows: an aliquot of $100\mu\text{L}$ of each K_3EDTA blood sample was treated with $600\mu\text{L}$ of 0.25% Triton X-100, 0.2% ammonium dihydrogen phosphate and 0.1% magnesium nitrate mixture in a 1.5mL tube. These substances isolate the Pb, stabilize it to 900°C and increase atomization efficiency. A volume of $20\mu\text{L}$ of each sample was loaded under the following parameters: 283.3 nm wavelength, 7A slit, D2 background correction, peak height. The alternative lead resonance line 283.3 nm was used to overcome any possible phosphate interference at the primary lead resonance line of 217 nm. The analysis was performed with a temperature and time program according to the manufacturer recommendation. The peak height recorded was measured during the assay procedure at 283.3 nm. Samples and standards were carried out in duplicate.

Statistical analysis was conducted using SPSS software (version 17, Chicago, IL, USA). For continuous variables, one-way ANOVA was used to compare differences among groups, and for categorical variables, Pearson's Chi square was used. Values were expressed as means \pm SD for continuous variables, and as number (%) for categorical variables. $P < 0.05$ was considered significant.

RESULTS

Table 1 shows participants' data according to age, number of working years and blood concentration of lead, divided according to workers groups. The total number of participants was 244 with age ranged from 18 to 61 years, and a mean age of 33.8 ± 7.1 . The number of working years ranged from 4 to 40 with a mean of 14.3 year. The working duration per day ranged from 6 to 13 hours with a mean of 9.7 hours. The five groups of workers did not significantly differ among each other in the average of age ($p = 0.327$) and average number of working years ($p = 0.232$). However, mean blood level of lead was significantly affected by working group. Taxi drivers, mechanics, and wood workers had significantly higher average lead blood level compared to other groups of workers ($P < 0.001$). No significant difference in the blood lead levels was observed among taxi drivers, mechanics, and wood workers ($P > 0.05$). Similarly, blood lead levels in hospital health workers and shop workers were not different ($P > 0.05$).

The symptoms according to lead concentration are shown in table 2. Workers with lead concentration $> 0.483 \mu\text{mol/L}$ ($10 \mu\text{g/dL}$) were more likely to have muscle pain compared to those with lower concentration (9.8% vs. 1.5%, $p\text{-value} = 0.033$). Other symptoms were not significantly different among volunteers according to the blood lead levels.

DISCUSSION

Findings of the current study indicate the higher exposure to lead among taxi drivers, automechanics, and wood workers compared to other workers groups. Additionally, muscle pain was significantly more observed in workers with lead blood level of more than $> 0.483 \mu\text{mol/L}$ ($10 \mu\text{g/dL}$). The results suggest the need for special safety precautions and interventional programs to promote healthy behavior among these workers groups, thus, limiting lead exposure.

In this study, higher lead exposure was observed among field worker such as taxi drivers, automechanics, and wood workers compared to other workers groups of mostly closed environment. These results are in accordance to previous studies, which showed that occupationally lead-exposed workers have higher blood lead concentration than those in non-exposed occupations

Table 1: Age, number of working years and blood concentration of lead, for the five studied groups of workers

Parameter	Hospital health workers N=36	Shop workers N = 67	Taxi drivers N = 15	Mechanics N = 49	Wood workers N = 77	P-value
Age (year): mean (SD)	33.4 (7.1)	34.8 (9.4)	36.9 (7.7)	32.7 (9.7)	33.3 (8.3)	0.413
Working years: mean (SD)	12.3 (2.4)	12.7 (6.0)	15.3 (8.9)	15.3 (9.2)	14.9 (8.4)	0.136
Blood concentration of lead (umol/L): mean (SD)	0.46 (0.11)	0.67 (0.58)	1.39 (0.68)	1.19 (0.82)	1.08 (0.61)	<0.0001

Table 2: Symptoms of lead poisoning according to blood lead concentration (0.483 umol/L = 10 ug/dL)

Symptom	≤ 0.483 umol/L	> 0.483 umol/L	P-value
Loss of Memory	0 (.0)	2 (1.4)	0.338
Loss of appetite	0 (.0)	1 (.7)	0.499
Dizziness	4 (6.2)	7 (4.9)	0.707
Constipation.	3 (4.6)	7 (4.9)	0.930
Muscle pain	1 (1.5)	14 (9.8)	0.033
Joint pain	3 (4.6)	16 (11.2)	0.127
Headache	6 (9.2)	14 (9.8)	0.899
Pallor	0 (.0)	1 (.7)	0.499
Hyperactivity	1 (1.5)	9 (6.3)	0.137
Numbness	2 (3.1)	8 (5.6)	0.431
Insomnia	2 (3.1)	3 (2.1)	0.669
Kidney problems	1 (1.5)	1 (.7)	0.565

(Hunaiti and Soud, 2000, Hunaiti *et al.*, 1995). Taxi drivers and mechanics are more exposed to lead polluted air from vehicles exhausts (Smith *et al.*, 2012). Mechanics are also highly exposed to various chemicals and industrial solvents used for car maintenance and repair (Capleton and Levy, 2005, Omokhodion, 1999). Wood workers are also exposed to significant amount of volatile chemicals/toxins used or generated during wood treatment (van Netten *et al.*, 1987, Bruscheiler *et al.*, 2012). On the other hand, health and shop workers are mostly working in enclosed areas with limited exposure to industrial chemical, solvents, and polluted air on highways and in busy city streets. Thus, occupational condition may have a substantial contribution to the observed variations in blood lead levels among different worker groups.

Early symptoms of lead poisoning in both adults and children, collectively known as colic, include abdominal pain, cramps, constipation, nausea, vomiting, anorexia, and weight loss. In adults, these symptoms manifest at blood-lead concentrations of over 3.86 umol/L (International Programme on Chemical Safety, 1995) and typically at concentrations of 4.82-9.64 umol/L. Bener *et al.*, (2001) reported that blood lead levels in industrial workers are strongly associated with symptoms including vomiting, dizziness, fatigue, muscular symptoms, irritability, memory disturbances, insomnia and allergic conjunctivitis, rhinitis and dermatitis. Additionally, they reported higher prevalence of respiratory symptoms for phlegm, shortness of breath and diagnosed asthma among industrial workers. Lead intoxication has a high

prevalence among those who are chronically over-exposed to lead. Arthralgia, headache, myalgia, depression, weakness, impotence, loss of libido, and vague gastrointestinal problems are among the reported symptoms (Moline and Landrigan, 2005). Chuang *et al.*, (2005) reported that lead workers tended to be exhausted more easily. They also tended to make notes to remind themselves to do things. According to Falk *et al.*, the challenge will be for developing countries to implement effective national and regional efforts to control sources of exposure to lead (Falk, 2003). In accordance, result of the current study showed significant association between blood lead concentrations and muscle pain. This indicates the importance of muscle pain as one of the most prominent symptom related to lead poisoning among workers. In fact, previous studies reported muscle pain as being one of the first reported symptoms of lead exposure (Stoleski *et al.*, 2008, Huupponen, 2005). Current results showed no correlation between blood lead levels and other known symptoms of lead poisoning. This could be due to comparatively lower level of blood lead detected in the samples compared to that observed worldwide (Bener *et al.*, 2001, Lanphear *et al.*, 2002, Kim *et al.*, 2003).

Results obtained in the current study show blood lead concentrations ranging from 0.463-1.39 umol/L in five lead-exposed groups of workers. In the year 1995, reports from Jordan have shown blood lead levels that were lower for non-suspected lead-exposed university students than workers such as mechanics, bus drivers, car painters and gas station workers with highest levels among metal casters (2.01umol/L) and radiator welder workers (1.58

umol/L) (Hunaiti and Soud, 2000, Hunaiti *et al.*, 1995). Our findings demonstrated an overall increase in blood lead concentrations among workers compared to that of the year 1995. However, even though there is an increase in blood lead level over the past 2 decades among workers in the study population, the detected levels are still below the values recorded for industrial workers in the nearby United Arab Emirates (Bener *et al.*, 2001). In comparison, blood lead levels among occupationally exposed population in North America ranged from 0.965 to 1.930 umol/L (Lanphear *et al.*, 2002). Similarly, Kim *et al.*, (2003) have reported significantly higher blood lead level in exposed worker group (1.49 umol/L) in Korea. Moreover, results from Turkey have shown similar trend (Gurer-Orhan *et al.*, 2004). Differences in blood lead concentrations among lead-exposed workers in different countries could be due to differences in workers age, number of working years and working duration per day, type of work, educational background and social factors.

Collectively, results of the current study show that certain occupationally lead-exposed workers are at significantly higher risk for lead exposure. Thus, special considerations must be directed toward lead blood levels and lead poisoning symptoms when medically examining these occupational groups. Additionally, monitoring, education, and prevention programs must be started specifically directed to these groups of workers.

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