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Original

Blood Lead Level of Workers in a Printing Industry

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Abstract

Background: Different chemical materials especially inks are used in printing industry and lead is one of the ingredients that make up its pigments. Therefore, the objectives of present study were to examine blood lead levels and determine the correlation between hygiene behaviors and blood lead levels among workers in one of the printing industry located in the west of Tehran province. **Methods:** In this cross-sectional study that conducted in 2018, 80 workers of a printing house were selected. Blood samples were collected according NIOSH 8003 method and analyzed using a graphite furnace atomic absorption spectrophotometer GF 5000 model. Data were analyzed by Mann-Whitney, Kruskal-Wallis and Spearman correlation test using SPSS 20. The significance level of 0.05 considered for results. **Results:** The range of blood lead levels was 0.0094 to 0.1968 ppb. Individuals who worked in printing patterns process on cardboard sheets had blood lead levels higher than those working in other processes in this printing house ($P < 0.001$). The workers who did not use masks ($P = 0.034$) and gloves ($P < 0.001$) had higher mean lead atomic absorption than the others. **Conclusion:** The lack of using personal protective equipment could potentially increase the blood lead levels in printing industry workers.

Keywords: Blood; Lead; Printing industry

Introduction

Workers in printing industry are faced with different materials, including organic solvents, mineral oils, pigments, resins, lead and paper dust.[1] One of the most important chemical materials used in the printing industry is ink, which is usually composed of a mixture of three main components: pigments, liquid phase or solvent, and resin. The pigments are suspended in the liquid medium during the milling process and may have an organic or mineral source. Mineral pigments include zinc oxide (white), lead sulfate, lead chromite and lead oxide (yellow, orange and red colors), iron oxide (yellow, red and brown) or black carbon pigments (black).[2]

The lead in the air enters the body through the inhalation and biological monitoring is considered as one of the most important routes for measuring the exposure of individuals to lead.[3] The blood system is one of the target organs of lead, and studies have shown that this element has a deleterious role in the structure of lipids and membrane proteins and inhibits the synthesis of hemoglobin.[4]

Several studies carried out over the last years regarding the complications and risks of this heavy metal.[5-10] A study on a group of workers with the modest exposure to lead in a printing industry, showed a strong relationship between gender and exposure to lead and the development of kidney

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and pancreatic cancers.[11] Another study on delivery outcomes of children of men exposed to lead and organic solvents in the printing industry, suggests that parents' exposure to lead has weak effect on birth weight, intrauterine growth, or the number of early childbirth.[12] The effects of low levels of exposure to lead in 1,261 typographics of the newspaper industry, showed that exposure to lead, even at levels below the permissible exposure limit in the United States, may also be linked to mortality from cerebrovascular disease.[13] Abdullahi et al.[14] found that workers in the printing industry were exposed to lead.

Regarding the harmful effects of lead on human health, such as anemia, kidney failure, hypertension, and cardiovascular disease, etc., also the presence of lead in ink pigments used in the printing industries, we examined the blood lead levels and determined its correlation with hygienic behaviors. We also examined the relationship between demographic and occupational parameters with blood lead levels.

Methods

Work environment and samples

In this cross sectional study, conducted in 2018, 80 male workers of a printing house located in Tehran province, were examined. In this industry, printing process included: printing patterns on cardboard sheets, Creating bumps and dents, removing extra straws from around the cardboard sheets and binding different angles with glue to make a box. These steps were carried out by different departments such as: printing, cutting, removing straws and binding, respectively. A number of workers worked in the administrative unit which according to their work, appeared in the production hall. Thus, all of samples in this study were exposed to lead fume during work shift. People who worked less than one year in the print shop were excluded from the study.

Data gathering tools

Due to ethical issues and in order to reduce the invasive effect of blood sampling, all measurements conducted as a part of routine periodic examinations. At the time of blood sampling, the informed consent form was signed by the participants in the study, and Iran University of Medical Sciences granted ethical permission for this study with the ethics code of IR.IUMS.REC.1396.32127.

A questionnaire about underlying variables including age, sex, smoking and its amount, work experience and educational level was provided. Also, in order to measure the frequency of hygienic behaviors, the subjects answered questions about: using protective gloves during handling chemicals, using protective masks during exposure to chemicals, washing hands before eating, taking a shower after work, eating and drinking at work with always, sometimes and never answers. BMI, systolic and diastolic blood pressure, and also blood hemoglobin were collected using the subject's medical records.

Blood lead analysis was performed according to the NIOSH 8003 (The National Institute for Occupational Safety and Health) method for all participants. Samples were collected in 6 ml EDTA K2 (Ethylenediaminetetraacetic acid K2) tubes and, kept for 3 days at 4 ° C. To prepare the specimens, 2 ml of whole blood sample mixed with 0.8 ml of Ammonium pyrrolidine dithiocarbamate-Triton X100 (APDC-TX) (CAS No: 5108-96-3 and 9002-93-1 respectively) surfactant solution made by TITRACHEM. two ml of aqueous saturated Methyl isobutyl ketone (MIBK) (Merk, (CAS No: 108-10-1)) were placed into the centrifuge tubes and then centrifuged for 10 minutes at 2000 rpm with a centrifuge machine (model D-7200 manufactured in Hettich company, Germany). Finally, all specimens were analyzed by the atomic absorption spectrometer (A.A) model GF 5000 (GBC company) with a graphite furnace manufactured in Australia.[15]

Due to the lack of normal distribution of quantitative data, Mann-Whitney and Kruskal-Wallis tests were used. Spearman correlation test was used to determine correlation between health behaviors and occupational and demographic parameters and variables in medical records with blood lead levels. The significance level of 0.05 considered for results. The data were analyzed using SPSS 20.

Results

The printing house workers' ages ranged between 24-56 years with mean of 34.20 (7.09) and the most of them were aged 30-40 years (62.5%). The largest group of workers (N = 52) had high school level education (65%). In terms of job features, 72.5% (N = 58) had work experience less than 10 years and 60.8% worked for 8 to 15 hours a day. Also, concerning medical and clinical records, workers' total hemoglobin concentration ranged between 10.6 – 16.9 g/Dl 14.45 (1.13) and the largest group of workers had BMI larger than 25 Kg/m2 (n = 52;

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65.8%). The mean and standard deviation of systolic and diastolic blood pressures in workers were 115.37 (6.35) and 65.68 (8.52) respectively see Table 1. The use of a questionnaire to examine the activity of the printing house workers in relation to health behaviors showed that the majority of workers always wash their hands before eating (98.7%) and take shower after daily work (90%).

The range of lead level in the blood was 0.0094 to 0.1968 ppb (mean 0.0847 ppb). Individuals who worked in process of printing patterns on cardboard sheets (n = 22) had higher blood lead levels than those worked in other processes Table 2.

Also, the majority of workers reported unhealthy behaviors, such as eating and drinking without washing hands at work (86.3%). Also, the largest group of them took a bath after working and 56.3% (N =45) always used gloves during work. Also 18.8% of the workers stated that they never used a mask while working Table 3.

Table 1. Comparison of mean blood lead level with different groups of medical records variables, demographic characteristics and job features

Quantitative variables		Number (%)	Mean blood Lead level (ppb) (SD)	*P*- value
Age (year)	< 30	17 (21.3)	0.0751 (0.0588)	0.011[1*]
	30 - 40	50 (62.5)	0.0946 (0.0457)	
	≥ 40	13 (16.3)	0.0590 (0.0372)	
Hemoglobin (g / dl)	< 14	11 (13.9)	0.0661 (0.0485)	0.0229[2]
	≥ 14	68 (86.1)	0.0883 (0.0488)	
Systolic blood pressure (mmHg)	< 120	46 (57.5)	0.0853 (0.0488)	0.946[2]
	≥ 120	34 (42.5)	0.0838 (0.0499)	
Diastolic blood pressure (mmHg)	< 70	53 (66.3)	0.0817 (0.0468)	0.945[2]
	≥ 70	27 (33.8)	0.0905 (0.0534)	
Working hours per day (hours)	< 10	24 (30.4)	0.0732 (0.0455)	0.645[1]
	10 - 15	24 (30.4)	0.0823 (0.0472)	
	≥ 15	31 (39.2)	0.09299(0.0514)	
Work experience (years)	< 10	58 (72.5)	0.0868 (0.0505)	0.335[1]
	10 - 20	18 (22.5)	0.0857 (0.0470)	
	≥ 20	4 (5)	0.0493 (0.0198)	
Body mass index (Kg / m2)	< 25	27 (34.2)	0.0856 (0.0541)	0.942[2]
	≥ 25	52 (65.8)	0.0848 (0.0469)	

1) Mann- Whitney Test
2) Kruskal- Wallis Test
*Statistical significance at p < 0.05
SD: standard deviation

Table 2. Comparison of blood lead levels and different process in the printing house

Process	Number (%)	Blood lead level (ppb) M (SD)	*P*- value
Administrative	7 (8.8)	0.0595 (0.0338)	< 0.001[1*]
Printing	22 (27.5)	0.1431 (0.0208)	
Cutting	12 (15)	0.0555 (0.0289)	
Removing straws	3 (3.8)	0.0806 (0.0525)	
Binding by glue	18 (22.5)	0.0665 (0.0377)	
Storing and services	9 (11.3)	0.0536 (0.0153)	
Repair and Maintenance	4 (5)	0.0722 (0.0466)	
Guarding	5 (6.3)	0.0441 (0.0247)	
Total	80 (100)	0.0847 (0.0490)	

1) Kruskal- Wallis Test
*Statistical significance at P < 0.05
M: mean
SD: standard deviation

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Table 3. Comparison between blood lead level and health behaviors of the printing house workers (n = 80)

Health behaviors	Answer	Number (%)	Blood lead level (ppb) M (SD)	*P*- value
smoking	yes	23 (28.8)	0.1195 (0.0431)	< 0.001[1*]
	No	57 (71.3)	0.0706 (0.0442)	
Using protective gloves during working	always	5 (6.3)	0.0562 (0.04461)	< 0.001[2*]
	sometimes	30 (37.5)	0.0579 (0.0305)	
	never	45 (56.3)	0.1057 (0.0498)	
Using a protective mask during working	always	27 (33.8)	0.0753 (0.0454)	0.034[2*]
	sometime	38 (37.61)	0.0772 (0.0477)	
	never	15 (18.8)	0.1202 (0.0448)	
Washing the hands before eating at work	always	78 (98.7)	0.0827 (0.0476)	0.483[2]
	sometimes	-	-	
	never	1 (1.3)	0.1289	
Taking a bath after working	always	72 (90)	0.0876 (0.05)	0.109[2]
	sometimes	-	-	
	never	8 (10)	0.0585 (0.0284)	
Eating and drinking at work	always	69 (86.3)	0.0872 (0.0492)	0.311[2]
	sometimes	-	-	
	never	11 (13.8)	0.0687 (0.0467)	

1) Mann- Whitney Test
2) Kruskal- Wallis Test
*Statistical significance at P< 0.05; M: mean; SD: standard deviation

There was no significant linear correlation between age and blood lead level (P = 0.736; rs = - 0.038) in samples. Also, There was no correlation between working hours and blood lead level (P = 0.202; rs = 0.145) while significant positive correlation was found between work experience and blood lead level (P < 0.001; rs = 0.533). Also, in terms of clinical and medical records, there was no significant linear correlation between systolic blood pressure and blood lead level (P = 0.738; rs = 0.038) so no significant correlation was found between diastolic blood pressure and blood lead level (P = 0.463; rs = 0.083) in samples. There was a significant negative correlation between hemoglobin concentration and lead absorption in participants (P = 0.050; rs = - 0.220). Also, there was no significant positive correlation between body mass index and blood lead level (P = 0.529; rs = 0.071).

The mean of blood lead level among smokers and non-smokers were 0.1195 (0.0431) ppb and 0.0706 (0.04423) ppb, respectively. The lead level of samples who never used mask when working had significantly higher lead levels than those who always did (P = 0.034). The samples who always used gloves when working had significantly lower blood lead levels than those who never did (P < 0.001). Also the blood lead level of workers who never washed their hands before eating had higher lead levels than those who always did, but it was not significant (P = 0.483). Relationship of taking shower after work (P = 0.109) and eating and drinking while working (P = 0.311) were not significant with blood lead levels' mean.

Discussion

This study was conducted to investigate the blood lead level among workers of a printing industry. A total of 80 printing industry workers participated in present study. We determined blood lead level correlation with hygienic behaviors. We also examined the relationship between demographic and occupational parameters with blood lead level. In addition to inhalation exposure with lead in work environments that can be very harmful even in low amounts,[16] the results of some studies indicate that several factors such as health behaviors, individuals and occupations factors affect lead poisoning.[17-19] In the present study, health behaviors such as smoking, using gloves and protective masks during work, washing hands before eating, taking a bath after leaving the workplace, as well as eating and drinking in the workplace were also investigated, however there was significant relationship between using protective mask and gloves and smoking with blood lead levels. This study showed that most of the workers who intervened in printing pattern on cardboards, did not use personal protective equipment effectively. The mean blood lead levels in workers who worked in process of printing was significantly higher than those who worked in other process of the printing house. It probably shows that these workers exposed to substances such as printing inks that made of leaden pigments. Humairo and Keman (2018) in a

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study on blood lead levels and healthy complaint in a printing industry found that there was no difference between blood lead level of production process employees and administration employees.[20] The present study is contrary to study of Humairo and Keman in this part but similar to its results about using gloves while working, increase hygienic and sanitation behavior.

Dehghan Nasiri et al. (2012) in a study on car soldering unit personnel in an automobile manufacturing, showed that people who did health behavior at work (using full-time masks and gloves, washing hands before eating at work and taking a shower after working), had a lower concentration of lead in comparison with control group 3. In 1985, Courtney and Meekin also assessed blood lead levels before and after laying down the rules such as no smoking ban, no eating and drinking at work, which resulted in a significant reduction in blood levels of individuals.[21] Ho et al, (1998) also showed high blood lead levels in the workers eating at work than the others.[22] This result agreed with Abdullahi et al.[23] that found workers in the printing industry were exposed to lead toxicity. Decharat et al. (2012) in a study of examination of blood lead levels in Thai Nielloware workers showed that the mean blood lead level was higher in workers who were smoker [24] and present study supported Decharat's study about smoking results. Regarding to results of present study, the lack of use of personal protective equipment could potentially increase the mean lead absorption in printing industry workers. Therefore training and education can help persons who work in printing houses and probably expose to lead fumes and other kinds of lead contaminants.

Aminipour et al. (2008) in a study on workers of zink Koushk mine, showed that the mean blood lead in individuals with different age groups was not the same and blood lead level in the older group was higher than younger group. They also showed that, with increased work experience, the level of blood lead in individuals also increased. However this was not statistically significant. In the study of Dehghan nasiri et al., There was a poor correlation between blood lead levels and age and work experience. As the age and work experience increased, so did lead concentration, but this increase was not statistically significant 3. Chu et al. also examined the correlation between blood lead in 1993 and 1994 with age, BMI, systolic and diastolic blood pressure, and there was no significant correlation between them.[25] In present study, in contrary to Aminipour's study, no significant correlation was found between ages with lead atomic absorption but this result supported Aminipour's study about work experience, also the result of the Chu study is consistent with this study about age. However the results showed that the mean of lead absorption in the age group of 30 to 40 years is higher than the rest of the age groups and maybe means that those who worked in printing process had the mean 30 to 40 years. Also, the results showed that there was not a significant relationship between lead atomic absorption and working hours, however, the average lead absorption was higher in people who worked more hours.[26]

Aminipour also showed that there was a reverse relationship between blood lead and hemoglobin, and this difference was significant.[3, 26] In the present study, like the results of Aminipour and Dehghan Nasiri's studies, there was a significant reverse correlation between hemoglobin concentration and blood lead absorption. However the mean of lead atomic absorption in two groups of hemoglobin concentration less than 14 g/dl and higher than 14 g/dl had no significant difference (P = 0.229). There was also no correlation between BMI, systolic and diastolic blood pressure on one hand and absorption rate on the other hand, which is consistent with the result of the Chu study.

Conclusion

Based on the results of this study, the mean of lead absorption in workers who worked in printing process was higher than that in other workers, which is statistically significant. One of the limitations of this study was the low number of participants and it is suggested that studies should be conducted on lead monitoring in larger printing house and with more samples so the effects of health behaviors and individual and occupational factors become more evident. Also, considering the relationship between the lead level in the respiratory air and in blood, it is suggested that coherent studies should be carried out in order to investigate this relationship in the printing industry.

Conflicts of Interest

The authors declare that they have no competing interests.

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