

BMJ Open Blood lead level risk factors and reference value derivation in a cross-sectional study of potentially lead-exposed workers in Iran

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ABSTRACT

Objectives This exploratory investigation aimed to measure blood lead levels and associated risk factors in exposed workers in Iran, and to derive appropriate reference values for blood lead in this population as a means of epidemiological comparison.

Design Cross-sectional.

Setting Manufacturing plants with potential lead exposure in Southern Khorasan Province, Iran.

Participants The study included 630 workers, selected through stratified random sampling.

Primary and secondary outcome measures The primary measures in this exploratory investigation were venous blood lead concentration (BLC) and associated risk factors of age, gender, work experience, cigarette smoking and history of opium use. The secondary measures were symptoms associated with lead toxicity. Data analyses were conducted using Student's t-test, Mann-Whitney U test, one-way analysis of variance, Kruskal-Wallis test, Spearman correlation coefficient and regression analysis.

Results Mean and median BLCs were 6.5 ± 8.1 µg/dL and 3.9 µg/dL (IQR: 2.9–5.8), respectively. Of the subjects, 85 (13.5%) had BLC ≥ 10 µg/dL. The derived reference BLC value in this study was 30 µg/dL for men and 14 µg/dL for women. Increasing work experience and age were associated with BLC > 10 µg/dL. Radiator manufacturers were up to 12.9 times (95% CI 4.6 to 35, $p < 0.005$) more likely than painters to have BLC > 10 µg/dL. Most subjects reported multiple symptoms.

Conclusions The mean BLC was above the maximum recommended concentration. There was a significant relationship between higher BLC and age or working in a printing factory or radiator manufacturing. These findings can direct efforts towards reducing occupational lead exposure.

INTRODUCTION

Lead is a widely used metal and a persistent poison that is extensively used in many industries for its chemical properties.^{1,2} The most important source of risk for lead poisoning is occupational, as it is used in more than

Strengths and limitations of this study

- To our knowledge, no current literature reports on reference lead concentrations in Iran, and few studies have been conducted in other countries.
- Generalisability to all workers may be limited by the random stratified sampling method and by the targeting of suspected lead-exposed industries.
- Reference values derived in this study are epidemiological in nature and do not imply thresholds for health effects.
- This study is exploratory and not hypothesis-testing.
- This study provides data that are valuable for future research and targeting of occupational public health resources.

900 industries, including battery and radiator manufacturing, ceramics, plumbing and paint.³ Lead exposure is toxic via ingestion, inhalation or dermal routes.^{4,5} Lead poisoning is a significant public health issue in Iran and other countries, and tremendous efforts have been undertaken to reduce occupational exposure in Iran since 1946.³

Over the past several decades, government agencies have been progressively lowering the upper blood lead concentration (BLC) limit considered not associated with harm. The US Centers for Disease Control and Prevention and the National Institute for Occupational Safety and Health now consider BLC > 5 µg/dL in adults elevated. The US Occupational Safety and Health Administration has emphasised workers with BLC ≥ 60 µg/dL should be removed from occupational exposure until BLC decreases to below 40 µg/dL.⁶ Lead poisoning symptoms, although non-specific in adults, include short-term memory loss, irritability, depressed mood, paraesthesias,

poor motor coordination, abdominal pain, headache and weight loss.³⁷

In the body, lead distributes to labile soft tissue and stable bone compartments. Lead interferes with the function of numerous proteins and can mimic divalent cations.⁸ Adverse effects include neuropathy, kidney damage, anaemia, immunocompromise, cognitive impairment and hypertension.^{9–10} There is also conflicting evidence for potential carcinogenicity.^{2,11} Due to its various toxic effects, elevated BLC is associated with increased mortality.^{12,13}

Reference values for a substance in human biological specimens, such as blood, are statistically obtained based on a series of measurements from an appropriately sampled portion of a population of interest. Reference values indicate the upper border of a detected substance in the population. There are numerous methods of deriving reference values, and the abbreviation RV95 was introduced in 2011, referring to rounded values of the upper limits of the 95% CIs of the 95th percentiles.¹⁴ Although the term reference value often refers to the range of laboratory values considered within a normal range, RV95 reference values in this study were derived as a means of comparing groups and are not intended for the purpose interpreting normal ranges for individuals.

Given lead poisoning is an ongoing major global public health issue, and since differences in occupational exposure regulations exist between countries, examining BLC in varying regions and among occupations can clarify the problem with granularity. The aims of this exploratory study were to measure BLC and its related factors, and to identify the reference values in workers who were probably exposed to this element in their current job in eastern Iran. This study on BLC in potentially lead-exposed workers can offer valuable reference data stratified by demographic and occupational factors. Given the significance of lead toxicity, it is prudent to implement biological monitoring programmes for lead in this occupational population, and the results from this study may assist in targeting efforts towards particular occupations.

METHODOLOGY

This was a cross-sectional study which enrolled 630 adult workers in 2017. Enrolment occurred in Southern Khorasan Province, Iran, of workers in tile manufacturing, radiator manufacturing, rubber production, mining, mechanics, printing and painting. A sample size of 630 total subjects was determined a priori based on prior literature, to achieve an α of 0.05 and β of 0.214. Enrolment occurred via stratified random sampling, which divided potential subjects into exclusive subgroups based on occupation, and subjects were randomly selected from each subgroup while taking into consideration the proportions and estimated sample size. A flow chart of subject enrolment is illustrated in figure 1. The selected number and frequency of workers in different occupations of radiator manufacturing, painting, mechanics, mining, rubber

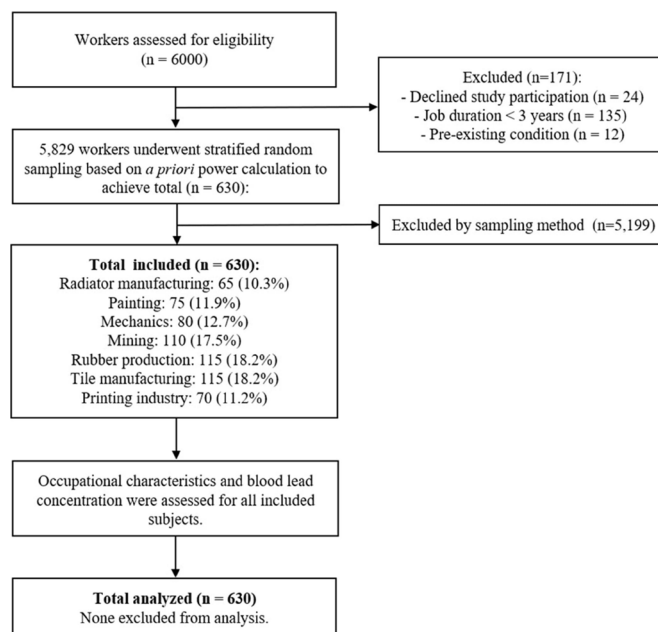


Figure 1 Flow diagram of subject enrolment.

production, tile manufacturing and printing industry were 65 (10.3%), 75 (11.9%), 80 (12.7%), 110 (17.5%), 115 (18.2%), 115 (18.2%) and 70 (11.2%), respectively.

Inclusion criteria were age ≥ 18 years old and workers with ≥ 3 years of experience in one of the potentially lead-exposed occupations. Subjects with known pre-existing conditions (anaemia, liver, kidney, neurological, gastrointestinal or cardiovascular disease) or active treatment of lead poisoning were not included. Written consent was obtained from all subjects.

Data on age, gender, work experience, cigarette smoking and history of opium use were collected. Opium use was evaluated as a potential confounding variable given prior literature demonstrating lead contamination of opium.¹⁵ A standardised symptom checklist instrument was used by trained study personnel to assess for symptoms of lead toxicity, including fatigue, abdominal colic, memory loss, weakness, muscular pain, irritability, constipation, anorexia and headache. To measure BLC, a 5 mL venous blood sample was obtained and placed on ice, then measured using graphite furnace atomic absorption spectroscopy (PG Instruments, AA500FG, UK). The calibration curve was based on ≥ 5 standard concentrations, using three control samples (Sero, Norway). Measurements were performed by trained technicians in the same laboratory, using the same equipment. In cases with elevated BLC $> 10 \mu\text{g/dL}$, both the worker and the employer were notified and referred for management.

Data were analysed using SPSS V.19. Descriptive indices were reported by group, including mean, SD, frequency, quartile and percentiles of BLC. Reference values in this study were determined based on the rounded upper limits of the 95% CIs of the 95th percentiles.^{11,16–20} If the BLC or urine samples of special groups of the community (eg, children, women and non-smokers) clearly differ from the general population, reference values should

be defined; however, if any significant relationship is observed between age and BLC, reference values are also required for some particular age groups.¹⁷ Since the term 'reference value' does not convey its method of derivation, the term RV95 was introduced in 2011 to reduce ambiguity.¹¹ The Kolmogorov-Smirnov test was used to examine normality of quantitative variables; if data were normally distributed, then independent t-test and analysis of variance were used, otherwise Mann-Whitney and Kruskal-Wallis tests were performed. Tukey's post-hoc test was used to compare BLC between groups. Multiple logistic regression was used to evaluate the relationship between demographic and occupational variables (type of occupation, duration of work experience) and BLC. P value <0.05 was considered significant.

Patient and public involvement

Subjects were not involved in the development of the research, study design, conduct or writing of this study.

RESULTS

A total of 630 subjects were enrolled, consisting of tile manufacturing (n=115, 18.2%), radiator manufacturing (n=65, 10.3%), rubber production (n=115, 18.2%), mining (n=110, 17.5%), mechanics (n=80, 12.7%), printing (n=70, 11.2%) and painting (n=75, 11.9%). These workers were enrolled from among the total employees in each occupation work site: radiator manufacturing (n=619), painting (n=714), mechanics (n=762), mining (n=1048), rubber manufacturing (n=1095), tile manufacturing (n=1095) and printing (n=667). There were 585 men (92.8%) and 45 women (7.2%). The mean age of subjects was 36.3±8.0 (range 23–62) years. The mean years of work was 18.7±9.4 (range 5.0–28.0), and the mean hours worked per week was 49.9±7.4 (range 14.0–210.0).

The major complaint among subjects was muscular pain (28.7%), followed by headaches (25.7%), irritability (19%), anorexia (14.6%), memory loss (11.4%) and abdominal colic (9.9%). Most subjects reported multiple symptoms. Figure 2 demonstrates the skewed distribution of BLC. The mean BLC was 6.5±8.1 µg/dL, the median was 3.9 µg/dL and the IQR was 2.9–5.8 µg/dL. Eighty-five (13.5%) subjects had BLC ≥10 µg/dL, and 545 (86.5%) had BLC <10 µg/dL. Of the participants, 188 (29.8%) and 7 (1.1%) had a BLC higher than 5 µg/dL and 40 µg/dL, respectively. The BLC of male subjects was significantly higher than female subjects, with median BLC of 9.0 µg/dL and 3.9 µg/dL, respectively. In the youngest age group (<30 years), the median BLC was 3.7 (IQR: 2.7–5.3) µg/dL, in the middle-aged group (30–45 years) was 3.9 (IQR: 2.9–5.9) µg/dL, and in the oldest age group (≥45 years) was 4.3 (IQR: 3.2–8.1) µg/dL. In this study, BLC reference values were 35 µg/dL for the oldest age group. Those with work experience less than 10 years had a median BLC of 3.7 (IQR: 2.7–5.4) µg/dL, those with work experience from 10 to 20 years had a median BLC

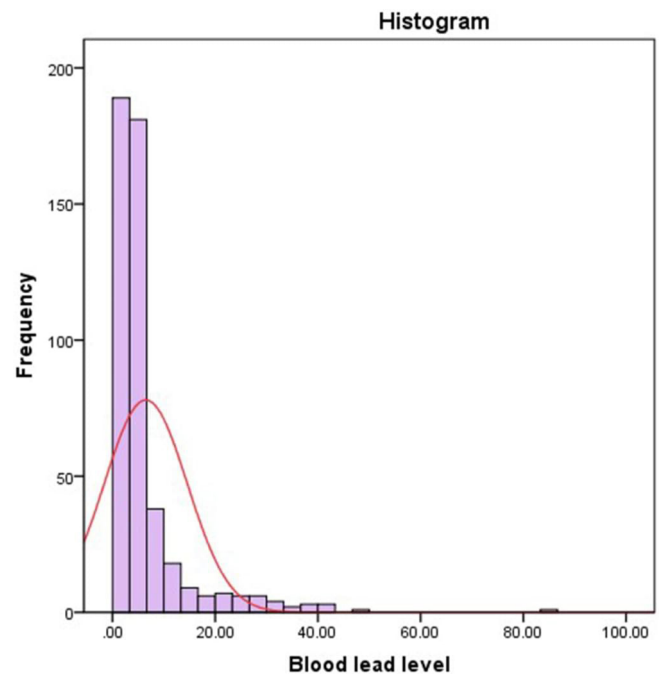


Figure 2 Estimated distribution of blood lead level in occupational exposure to lead.

of 3.9 (IQR: 3.02–6.0) µg/dL, and those with more than 20 years of work experience had a median BLC of 4.0 (IQR: 2.9–5.0) µg/dL.

The Kruskal-Wallis test showed that lead concentrations differed between occupations ($\chi^2=54.25$, $p<0.001$). In radiator manufacturers, the mean BLC was 22.4±13.1 µg/dL, the median was 23.2 (IQR: 9.0–32.4) µg/dL and the RV95 reference value was 43 µg/dL. In the printing factory, the median BLC was 4.9 (IQR: 3.2–15.8) µg/dL, with an RV95 reference value of 39 µg/dL, which was significantly higher than rubber manufacturing with a median of 3.9 (IQR: 3.1–4.9) µg/dL ($p=0.004$) and mechanics with a median of 3.3 (IQR: 2.5–4.2) µg/dL ($p=0.003$).

The BLC in radiator manufacturers was significantly higher than in other occupations ($p<0.001$) (table 1). The BLC RV95 reference values in radiator manufacturers in the youngest (<30 years) and intermediate (30–45 years) age groups were 43 µg/dL and 42 µg/dL, respectively. Among workers in the printing factory, mechanics and radiator manufacturing, the BLC RV95 reference values increased with longer work experience (table 2).

Based on the multiple logistic regression adjusting for opium use, cigarette smoking and work experience, higher BLC was significantly correlated with age and working in printing factory and radiator manufacturing (table 3). The results showed that for each year of increasing work experience, the chance for BLC >10 µg/dL increases by 1.07 times (OR: 1.07, 95% CI 1.03 to 1.13, $p=0.002$). In radiator manufacturers compared with painters, it was 12.93 times more likely to have BLC >10 µg/dL (OR: 12.93, 95% CI 4.56 to 34.98, $p=0.002$). The Hosmer-Lemeshow goodness-of-fit test was insignificant ($\chi^2=5.38$, $df=8$,

Table 1 Percentile, means and reference values derived for blood lead level according to different variables using descriptive analysis

Group	P10	P25	P50	P75	P90	P95	95% CI	RV95	Mean
Age (years)									
<30	2.1	2.7	3.7	5.2	12.2	22.4	13.7 to 31.9	32	5.9
30–45	2.1	2.9	3.9	5.9	13.4	21.1	17.4 to 38.5	39	6.5
≥45	2.1	3.2	4.3	8.1	24.4	30.0	23.6 to 34.5	35	7.9
Work experience (years)									
<10	2.1	2.7	3.7	5.4	14.9	28.9	21.7 to 34.5	35	6.1
10–20	2.4	3.02	3.9	6.0	10.2	16.3	10.2 to 23.4	24	5.5
≥20	2.2	2.9	4.0	5.0	12.1	23.3	9.7 to 38.8	39	6.8
Gender									
Male	2.1	2.9	9.0	11.7	14.3	25.06	19.5 to 29.5	30	8.4
Female	1.9	5.2	3.9	9.5	13.3	13.3	10.8 to 13.3	14	6.4
Occupation									
Printing factory	2.9	3.22	4.9	15.8	27.4	36.2	23.02 to 38.5	39	10.6
Tile manufacturing	2.01	2.7	3.5	4.7	8.7	14.2	9.1 to 36.9	37	5.2
Mining	2.0	2.3	4.1	8	16.2	24.5	16.2 to 39.02	40	7.1
Rubber manufacturing	2.5	3.1	3.9	4.9	7.6	9.4	7.7 to 17.8	18	4.7
Mechanic	2	2.5	3.3	4.2	7.8	10.3	6.4 to 20.2	20	4.1
Painter	2.7	3.2	4.1	4.7	6.8	19	4.7 to 19.0	19	4.7
Radiator manufacturing	3.7	9.0	23.2	32.4	42.3	42.60	34.7 to 42.6	43	22.4
Opium use									
Yes	2.8	3.6	5.5	13.8	22.9	26.6	21.1 to 30.6	31	9.3
No	2.1	2.9	3.8	5.2	12.5	24.9	17.1 to 30.1	31	6.2
Cigarette smoking									
Yes	2.1	3.6	4.4	10.4	20.1	30.6	17.9 to 38.8	39	8.3
No	2.1	2.9	3.9	5.6	12.9	25.1	17.4 to 29.5	30	6.3

P, percentile; RV95, rounded values of the upper limits of the 95% CIs of the 95th percentiles.

$p=0.72$). Thus, the null hypothesis claiming the model fit the data well could not be rejected. Cox and Snell's pseudo-R-squared was 30%, which suggests independent variables contributed to predicting BLC of $>10 \mu\text{g}/\text{dL}$.

DISCUSSION

This study aimed to explore factors related to elevated BLC in workers in eastern Iran. The results showed the mean BLC was $6.5 \pm 8.1 \mu\text{g}/\text{dL}$ (range 1.1–83.5). The mean BLC values were $>5 \mu\text{g}/\text{dL}$ in 29.8%, $>10 \mu\text{g}/\text{dL}$ in 13.5% and $>40 \mu\text{g}/\text{dL}$ in 1.1% of the subjects.

The mean BLC was above the $5 \mu\text{g}/\text{dL}$ recommended by the Centers for Disease Control and Prevention. Further, the US Occupational Safety and Health Administration recommends workers with BLC ≥ 50 (construction) or BLC ≥ 60 (general industry) be removed from their occupational exposure until their BLC was below $40 \mu\text{g}/\text{dL}$, and this recommendation would apply to a portion of subjects in this study.⁶

The RV95 provides a basis for identifying individuals or subpopulations with higher mean blood lead level (BLL). So individuals aged 30–45 years, with work experience of 20 years or higher, male, radiator manufacturing workers, opium users and cigarettes smokers with 95% confidence have higher mean BLL in comparison with other subgroups of individuals.

Predicting factors of higher BLC using multiple logistic regression analysis after covariation of opium use, cigarette smoking and work experience were age and radiator manufacturing occupation.

A meta-analysis in Iran that investigated 34 studies of occupational lead exposure found the mean BLC in Iranian workers was $42.8 \mu\text{g}/\text{dL}$ (95% CI 50.5 to 15.4).²¹ The lowest mean BLC occupationally in Iran was $4.98 \mu\text{g}/\text{dL}$ and the highest was $96.7 \mu\text{g}/\text{dL}$ in Tehran in 2004.²² Alasia *et al*²³ found the mean BLC of 190 lead-exposed workers (including welding/metal work, paint/pigment work, radiator repair, battery work and petrol work) was $50.4 \pm 24.6 \mu\text{g}/\text{dL}$.

Table 2 Percentile, means and reference values derived for blood lead level according to different occupations stratified by age and work experience using descriptive analysis

Occupation	Age (years)	P10	P25	P50	P75	P90	P95	95% CI	RV95	Mean
Printing factory	<30	2.8	3.0	3.9	16.7	27.0	29.5	19.7 to 29.5	30	9.8
	30–45	3.3	4.2	6.8	17.8	38.5	38.5	10.3 to 38.5	39	11.8
	≥45	3.0	3.0	11.1	23.4	23.4	23.4	12.7 to 23.4	24	12.5
Tile making	<30	2.0	2.7	3.4	4.5	7.2	12.6	7.2 to 25.2	26	4.3
	30–45	1.9	2.2	3.4	5.5	25.4	42.1	10.4 to 48.4	49	7.3
	≥45	2.1	3.5	4.1	8.4	10.4	10.4	6.8 to 10.4	11	5.4
Mining	<30	2	2.3	4.1	8.0	11.8	14.6	9.7 to 15.0	15	5.4
	30–45	2.0	2.3	3.9	7.5	17.7	27.1	16.7 to 83.5	84	7.7
	≥45	1.5	2.07	4.9	18.2	27.9	31.2	22.6 to 31.2	32	9.8
Rubber manufacturing	<30	2.1	2.7	3.5	4.1	8.5	35.5	4.8 to 36.9	37	5.3
	30–45	2.6	3.1	3.9	5.05	7.5	9.6	7.5 to 17.9	18	4.6
	≥45	2.6	3.1	4.0	4.9	8.1	13.2	5.0 to 15.4	16	4.6
Mechanics	<30	2.0	2.6	3.6	4.4	10.1	15.1	7.8 to 20.2	21	4.6
	30–45	1.6	2.4	3.3	4.2	6.3	9.9	4.7 to 10.3	11	3.6
	≥45	1.5	2.9	3.2	3.9	4.4	4.4	3.5 to 4.4	5	3.2
Painting	<30	2.7	3.3	3.7	4.6	6.5	6.8	4.6 to 6.8	7	4.0
	30–45	2.7	2.7	3.4	8.2	19.0	19.0	4.4 to 19	19	6.0
	≥45	4.6	4.6	4.7	4.8	4.8	4.8	4.7 to 4.8	5	4.7
Radiator manufacturing	<30	3.3	3.8	26.4	36.7	42.6	42.6	36.2 to 42.6	43	22.1
	30–45	8.4	9.5	20.8	28.4	42.0	42.0	24.9 to 42.0	42	20.6
	≥45	9.0	18.4	26.2	32.9	34.5	34.5	31.07 to 34.5	35	25.0

Occupation	Work experience (years)	P10	P25	P50	P75	P90	P95	95% CI	RV95	Mean
Printing factory	<10	2.9	2.9	14.15	25.4	25.4	25.4	8.2 to 25.4	26	8.5
	10–20	2.9	3.2	4.9	14.1	27.6	37.1	21.5 to 38.5	39	10.3
Tile manufacturing	<10	2.0	2.5	3.5	4.7	7.5	13.7	7.3 to 41.3	42	4.9
	10–20	2.1	2.4	3.15	3.8	9.5	14.5	3.8 to 14.5	15	3.8
	≥20	2.8	2.8	6.7	19.6	38.8	38.8	12.4 to 38.8	39	11.8
Mining	<10	1.9	2.2	3.4	6.1	12.2	24.3	11.6 to 78.8	79	11.8
	10–20	5.5	6.1	10.1	16.2	22.7	26.6	16.9 to 26.6	27	24.7
Rubber manufacturing	<10	2.7	3.3	3.8	4.1	4.8	32.1	4.5 to 36.9	37	5.2
	10–20	2.6	3.0	3.8	5.1	7.8	8.8	7.5 to 17.4	18	4.5
	≥20	2.2	3.0	3.9	4.9	7.7	12.5	5.5 to 18.0	18	4.5
Mechanics	<10	1.5	1.5	3.3	3.3	4.4	4.4	3.2 to 4.4	5	3.3
	10–20	2	2.5	3.3	4.1	8.0	10.4	6.7 to 20.2	21	4.1
Painting	<10	2.7	3.2	4.1	4.7	6.8	19.0	4.7 to 19.0	20	4.7
Radiator manufacturing	<10	3.8	9.0	21.6	33.5	33.5	33.5	25.6 to 33.5	34	22.4
	10–20	3.6	8.9	25.3	33.4	42.4	42.6	35.4 to 42.6	43	23.1

P, percentile; RV95, rounded values of the upper limits of the 95% CIs of the 95th percentiles.

Many studies have emphasised the high concentrations of lead in occupationally exposed workers compared with non-occupationally exposed people, including a Nigerian study with a mean BLC in exposed workers of $56.3 \pm 1.0 \mu\text{g/dL}$ vs $30.5 \pm 1.4 \mu\text{g/dL}$ in controls.²⁴ BLC in a group of Korean workers was $32.0 \pm 15.0 \mu\text{g/dL}$ compared with

$5.8 \pm 1.8 \mu\text{g/dL}$ in controls.²⁵ No prior study has examined BLC reference values in workers in Iran, and the number of studies conducted in other countries is limited. In a Taiwan study, lead reference values in exposed workers were $40 \mu\text{g/dL}$ and $30 \mu\text{g/dL}$ in men and women, respectively. Reference values in the Czech Republic

Table 3 Predicting factors of higher blood lead concentration using multiple logistic regression analysis after covariation of opium use, cigarette smoking and work experience

Variables	B coefficient (SE)	OR (95% CI)	P value
Age	0.02 (0.02)	1.02 (0.98 to 1.05)	0.06
Gender			
Female	Reference		
Male	0.64 (0.41)	1.90 (0.84 to 6.13)	0.31
Occupation			
Painting	Reference		
Printing factory	2.21 (0.99)	9.11 (6.14 to 18.52)	0.01
Tile making	0.13 (0.89)	1.13 (0.54 to 8.63)	0.58
Mining	0.99 (0.71)	2.69 (0.74 to 6.36)	0.11
Rubber manufacturing	-1.74 (1.09)	0.17 (0.08 to 1.25)	0.19
Mechanics	0.10 (0.95)	1.10 (0.45 to 3.58)	0.56
Radiator making	2.43 (1.03)	11.35 (5.32 to 21.35)	0.001

among non-exposed people were 8 µg/dL and 5 µg/dL, respectively, for adult men and women.²⁶ For potentially carcinogenic agents, or substances with no clearly defined biological permissible concentration, RV95 may be applied in risk assessment. The German Human Biomonitoring Commission¹¹ suspended lead concentration threshold values given the lack of evidence establishing safe exposure limits. Inorganic lead compounds were upgraded by the International Agency for Research on Cancer as group 2A (probable carcinogens).

Some other studies based their reference value on different percentiles, such as 97.5th percentile and its 90% CI or the 90th percentile with/without its 95% CI.^{27–29} However, the definition and operationalisation of reference values vary even more, depending on the national study.

The benchmark US National Health and Nutrition Examination Survey has found decreasing mean BLCs, from 1.65 µg/dL in 1999–2000 to 0.84 µg/dL in 2013–2014.³⁰ Moayedi *et al*³¹ found BLC was associated with age group. Kim and Lee³² also found the mean BLC in people >40 years old was significantly higher than those under 40. Kuno *et al*²⁰ in Brazil also found older people had 23% higher BLCs. The association between BLC and age has been reported in many other studies, with older people having higher lead concentrations.^{33 34} Older people are exposed to more lead during their lifetime, which distributes to both the labile soft tissue and stable bone compartments.³²

This study found BLC in men was significantly higher than in women. This finding is consistent with numerous studies globally.^{18 33 34} Potential explanations include occupational differences, or that higher oestrogen in women may increase lead distribution to the stable bone compartment with subsequent slow release.^{33 34} Haemoglobin levels are also generally higher in men, and since lead is measured in whole blood this may contribute to the differences noted in multiple studies.^{33 34}

This study found, among occupations investigated, that working in radiator manufacturing or printing factory increases the risk of lead poisoning significantly. Lead poisoning among radiator manufacturers has also been reported in prior literature.^{8 35 36} Lead-containing solder is commonly used in radiators and puts workers at risk of inhaling lead fumes and dust.³⁷

In numerous studies, high BLC has been found in painters.^{38 39} Lead is used in paints for its anticorrosion properties, and since 1984 lead in household paint has been banned in most countries. However lead is still used in non-household paint, and regulations in paint vary by country.^{8 40}

Occupational hygiene practices modify exposure to lead and are particularly relevant in non-industrialised countries. These practices include poor sanitation, inadequate personal protection such as masks, gloves and aprons, eating in the workplace, or lack of hand washing prior to eating.⁸ Further, in developing countries these repair shops and factories are often proximate to residential homes.

CONCLUSION

This research provides an estimation of BLC in occupationally exposed workers in eastern Iran. A significant association was observed between BLC and age and working in radiator manufacturing or printing factory. The findings of this study demonstrate the ongoing need for further improvements in occupational regulations and adherence.

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