

A Comparative Health Assessment of Occupationally Lead Exposed Individuals with Blood Lead Levels Range across Upper Acceptable Limit

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Abstract

Context: Lead (Pb) smelting workers are exposed to high lead levels and its adverse health effects. Despite no biological role, regulatory bodies regard blood lead levels (BLL) ≤ 40 $\mu\text{g/dL}$ as upper acceptable limit in occupationally lead exposed population. **Objective:** To explore the differences in general health status of individuals with BLL ≤ 40 $\mu\text{g/dL}$ and >40 $\mu\text{g/dL}$. **Methods:** All workers ($n = 803$) of age >18 years employed in a Pb smelting plant were interviewed with a semi-structured questionnaire to obtain sociodemographics, occupational details, followed by detailed clinical examination. 5 ml of venous blood was collected and BLLs were determined as per standard NIOSH method using GF-AAS technic. A complete general health status was performed including hemoglobin and blood pressure (BP). **Results:** About 47.7% of the participants exhibited high BLL (>40 $\mu\text{g/dL}$), while the rest 52.3% were identified to have ≤ 40 $\mu\text{g/dL}$. Both groups were grossly similar in the majority of demographic and occupational parameters. Interestingly, both groups had substantially higher fraction of workers with elevated BP. **Conclusions:** Lead exposed workers with BLL ≤ 40 $\mu\text{g/dL}$ are at equal risk of health hazards as those with BLL >40 $\mu\text{g/dL}$. There is a need to revisit the current guidelines on the BLL for workers to protect from the hazards of chronic lead exposure.

Keywords: Anaemia, blood lead levels, blood pressure, occupational lead exposure, upper acceptable limit

INTRODUCTION

Lead (Pb), a heavy metal due to its multiple desirable properties, has been in continuous usage since ancient time.^[1] Therefore, humans are continuously exposed to Pb either due to occupational or environmental causes.^[1,2] However, with advancement in health sciences, any levels of Pb exposure are recognized as detrimental to human health.^[3] Hence, various international and national regulatory bodies have prescribed guidelines to protect and prevent the health consequences of Pb exposure.^[4] Occupational Safety and Health Administration (OSHA), USA suggested 40 $\mu\text{g/dL}$ as upper acceptable limit for blood lead levels of individuals occupationally exposed to lead.^[4] The OSHA guidelines are accepted and adhered globally for ensuring safe and healthy industrial practices.

Pb (lead) at any levels in the biological samples is unacceptable; thereby individuals with no history of occupational Pb exposure exhibiting BLL >10 $\mu\text{g/dL}$ are recommended for

regular medical surveillance to detect the possible health effects as well the source of Pb exposure.^[5]

Therefore, it is imperative to understand the difference in the general health status of individuals occupationally exposed to Pb with BLL >40 $\mu\text{g/dL}$ as compared to those with BLL ≤ 40 $\mu\text{g/dL}$.

The present study involved occupationally lead exposed workers (lead smelting plant) to explore the differences in the general health status between those with BLL >40 $\mu\text{g/dL}$ and BLL ≤ 40 $\mu\text{g/dL}$.

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SUBJECTS AND METHODS

A total of 803 (>18 years of age) workers employed at a Pb smelting plant were investigated for health effects of occupational lead exposure as a part of the occupational health evaluation. Institutional ethical clearance was obtained before initiate the study. All consenting participants were interviewed with a semi-structured questionnaire to obtain sociodemographics, occupational details, followed by detailed clinical examination by a physician including measurement of blood pressure (BP). 5 ml of venous blood was collected using sodium heparin-coated vials under aseptic precautions. About a drop of blood was used to evaluate the hemoglobin using Hemocue and categorized as anemia and normal levels as per WHO guidelines.^[6] Blood samples were transported and stored ensuring cold chain.

BP was measured according to the recommendations prescribed by American Heart Association.^[7] Briefly, the BP was measured ensuring the worker was at ease using a precalibrated digital sphygmomanometer (Omron HealthCare, Kyoto, Japan). Each participant was evaluated thrice with 3–5-min interval between each measurement and the average of second and third measurement was considered for the study. Individuals were categorized as prehypertensive, hypertensive according to the guidelines prescribed by The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High BP.^[8]

The assessment of BLL was performed as per method no. 8003 of NIOSH manual of analytical methods using GF-AAS (AAlyte 800, Perkin Elmer, USA) technique. Detailed methodology is described elsewhere.^[9]

The statistical analysis was performed by Statistical Package for the Social Sciences (SPSS) version 17.0 software (Chicago IL, USA).^[10] The study population was categorized as “high BLL” group and “acceptable BLL” group, respectively, if their BLLs were >40 µg/dl and ≤40 µg/dl.^[4] All statistical tests were regarded as significant at $P < 0.05$.

RESULTS

Workers with BLL >40 µg/dL and ≤40 µg/dL were, respectively, categorized as “high BLL” and “acceptable BLL.” Workers from both groups were similar in terms of age (35.57 ± 7.28 vs. 35.05 ± 7.23 years) and duration of work (96.23 ± 32.53 vs. 96.76 ± 43.52 months). Workers categorized as high BLL were significantly from lower educational background as compared to the “acceptable BLL” group, i.e., 46% of the “high BLL” group had not educated beyond primary school, whereas 74.8% of the “acceptable BLL” group attained education higher than primary school. The socioeconomic status distribution across the two groups (i.e. high BLL group and acceptable BLL group) was relatively similar. All workers were provided with safe drinking water (filtered) at workplace, while majority (75.6%) of them expressed usage of filtered/packaged/ground water sources for consumption at their residences. The “acceptable

BLL” group exhibited significantly reduced tobacco usage (31% vs. 59%) as compared to “high BLL” group.

Workers from both groups were grossly similar in terms of units of employment, nature of job, and type of employment. However, BLL was significantly different within the groups, i.e., contractual workers exhibited significantly higher BLL as compared to permanent workers, while intuitively administrative workers had least BLL and workers continuously handling lead had higher BLL [Table 1].

Significantly higher proportion of workers with “High BLL” reported of dyspnea and musculoskeletal symptoms, while both groups were similar in terms of reporting gastrointestinal symptoms, neurological symptoms, and other respiratory symptoms (cough, phlegm, and chest pain) [Table 2].

The distribution of normal BP, prehypertension (elevated), Stage 1 and 2 hypertension was similar between the two groups. Interestingly, 44.5% of the workers (irrespective of BLL) exhibited BP in prehypertensive levels, while alarmingly, 23% of the workers had levels requiring medical attention (hypertensive levels). Significantly higher fraction of “high BLL” group exhibited clinical pallor and low Hb levels (anaemia) as compared to the “acceptable BLL” group [Table 3].

DISCUSSION

The present study involved all workers employed in a particular Pb smelting plant to explore differences in the general health status of workers exhibiting BLL >40 µg/dL as compared to those with BLL ≤40 µg/dL. Briefly, the workers with BLL ≤40 µg/dL had significantly higher years of formal education, better life style practices (in terms of tobacco usage) as compared to workers with BLL >40 µg/dL. Further, both the groups of workers were similar in all general health status parameters except for hemoglobin status.

As workers with administrative and supervisory roles were sparingly exposed to Pb refining process, relatively lower proportion of workers with administrative and supervisory responsibilities exhibited “high BLL.” While workers directly engaged in Pb smelting processes exhibited variable BLL and thereby the study observed relatively equal distribution of these workers in either of “high BLL” or “acceptable BLL” groups. Individual factors such as duration of exposure, age, concomitant environmental (or other source of) exposure, and individual variations in metabolism are posited for the variations in BLL among workers.^[3] Despite longer duration of employment, higher proportion of workers with permanent employment (regular payroll) exhibited acceptable BLL; however, the proportion of workers with contractual employment exhibited were similar across the “high BLL” and “acceptable BLL” groups. As steps of administrative control recommended by OSHA and other regulatory bodies, workers with high BLL should be mandatorily transferred to unit (department) with relatively lower levels of airborne

Table 1: Blood lead level and job profile of the workers

Employment factors	BLL >40 µg/dL (n)	BLL ≤40 µg/dL (n)	Total (n)	Mean BLL±SD
Department				
Raw material	7	9	16	38.54±14.12
Furnace	200	210	410	39.08±13.43
Electro chemical refinery	162	151	313	39.62±12.87
Maintenance	9	16	25	31.02±13
Other	5	34	39	23.57±11.6
Nature of job/roles and responsibilities				
Administration	7	20	27	30.57±13.69
Supervisor	59	101	160	35.22±14.87
Worker	317	299	616	39.41±13.02
Type of employment				
Permanent	56	110	166	33.62±1.17
Contractual	327	307	634	39.59±0.51

BLL: Blood lead level, SD: Standard deviation

Table 2: Clinical symptoms among “high blood lead level” and “acceptable blood lead level” workers

	BLL (µg/dL) (%)		Total (%)	Significance (P)
	>40	≤40		
<i>n</i>	383	420	803	
Respiratory symptoms				
Cough	22 (5.7)	25 (6.0)	47 (5.9)	0.900
Phlegm	9 (2.3)	12 (2.9)	21 (2.6)	0.653
Dyspnea	75 (19.6)	52 (12.4)	127 (15.8)	0.005
Chest pain	17 (4.4)	14 (3.3)	31 (3.9)	0.417
GIT symptoms				
Presence	72 (18.8)	100 (23.8)	172 (21.4)	0.05
CNS system				
Headache	57 (14.9)	42 (10.0)	99 (12.3)	0.036
Memory loss	30 (7.8)	9 (2.1)	39 (4.9)	0.0001
Musculoskeletal symptoms				
Presence	100 (26.1)	36 (8.6)	136 (16.9)	0.001

BLL: Blood lead level

Pb.^[4] For reasons, the contractual (less skilled) workers being the choice for frequent transfer among various units and the need to exercise the administrative control, the proportion of contractual workers in the present study were relatively evenly distributed between the “high BLL” and “acceptable BLL” groups.

The current study observed relatively similar proportion of clinical symptoms between workers with acceptable BLL and high BLL group. Notably, relatively higher proportion of workers with “high BLL” exhibited anemia, as compared to those with “acceptable BLL,” while the frequency of other clinical parameters was grossly similar in workers of both groups. Intriguingly, irrespective of their BLL status, a whopping 44.5% of these workers exhibited prehypertension status and another 23% of workers required medical attention in view of elevated BP. In contrast, the national prevalence of prehypertension and hypertension in general population as reported in “National Family Health Survey – 4” is, respectively, 36% and 13%.^[11] Hence, occupational lead

exposure is certainly detrimental to cardiovascular health irrespective of the levels being within the acceptable BLL. As reduced heme synthesis (anemia) and elevation of BP are well documented health hazards of chronic lead exposure,^[12,13] the same is observed in the present chronic (occupationally) Pb exposed workers.

The study intended to revisit the OSHA’s guidelines in terms of the health effects among those workers occupationally exposed to Pb with BLL >40 µg/dL as compared to those with ≤40 µg/dL. Previously, the committee for US military firing range workers has emphasized the possible health effects at relatively lower levels of BLL such as elevated BP at BLL around 10 µg/dL, altered hematological parameters at BLL as low as 20 µg/dL, and many more.^[4,14] Under the light, any levels of Pb in biological samples (blood) are detrimental to human health and the results of present study, i.e., similarity in general health status between the two groups, the acceptable levels of BLL need to be revisited and reduced.

Table 3: Distribution of blood lead level as per clinical and laboratory parameters

	BLL ($\mu\text{g/dL}$) (%)		Total (%)	Significance (<i>p</i>)
	>40	≤ 40		
<i>n</i>	383	420	803	
The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure ^[8] (%)				
Normal	109 (28.4)	147 (35.0)	256 (31.9)	0.248
Prehypertensive (elevated)	181 (47.2)	176 (41.9)	357 (44.5)	
Stage-1	74 (19.4)	78 (18.6)	152 (18.9)	
Stage-2	19 (5.0)	19 (4.5)	38 (4.7)	
Clinical examination (%)				
Pallor	105 (27.4)	77 (18.3)	182 (22.7)	0.002
Clubbing	14 (3.6)	8 (1.9)	22 (2.7)	0.281
Blue line gums	13 (3.3)	8 (1.9)	21 (2.6)	0.372
Anemia (%)				
Anemic	59 (15.4)	37 (8.8)	96 (12.0)	0.004
Normal	324 (84.6)	383 (91.2)	707 (88.0)	

CONCLUSIONS

Workers from both group exhibited similar patterns of general health issues, suggesting the workers with BLL $\leq 40 \mu\text{g/dL}$ are equally prone to lead induced detrimental health effects as those workers with BLL $>40 \mu\text{g/dL}$. Workers exposed to heavy metals (e.g. Pb) should be periodically (half yearly) evaluated for any deviation in health status. Any worker with deviation in the health status, irrespective of the levels of heavy metals in their biological samples should be investigated and necessary control action (either engineering, administrative, or personal measures) should be immediately exercised. The present study was limited by brief evaluation of general health status and lack of precise measurement of the workplace Pb exposure levels. Future studies exploring the health consequences of exposure to various levels of Pb need to be investigated involving larger sample size and longitudinal study design. The regulatory bodies should consider additional measures for workers' safety.

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Conflicts of interest

There are no conflicts of interest.

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