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A study on health profile of workers in a battery factory with reference to lead toxicity: six months study

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ABSTRACT

Background: Occupational health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations. Among the occupational diseases, diseases due to chemical agents like chemical gases, inorganic and organic dusts, metals and their compounds, chemicals and solvents constitute one important group. Workers engaged in lead industries like gasoline additives, lead based paints, ceramic glazes, plumbing of pipes are continuously exposed and are at a greater risk of lead toxicity. The present study was aimed to emphasize the health profile of workers in a battery factory and with reference to their blood lead levels and correlation with signs and symptoms of lead toxicity.

Methods: A prospective cross sectional study was conducted among workers for 6 months period and health details were evaluated along with demographic data (age, duration of work, etc.) and examined for signs and symptoms of lead toxicity. Blood lead levels of the workers were estimated and correlated with other parameters like Hb%, serum creatinine.

Results: Mean blood lead levels of the workers were high among the workers working for longer duration in battery fitting unit. Toxicity signs and symptoms were observed and they were attributable to lead toxicity. Few cases had audiometric disturbances and one had loss of vision. High levels of lead in blood were found to be related to hypertension and anemia among the workers.

Conclusions: Heavy metal, lead is a major environmental pollutant and its toxicity continues to create health problems in several segments of the population. There is urgent need for the prevention and control of lead toxicity by strengthening the systematic screening for blood lead levels compatible with sub clinical lead toxicity and a routine case finding for hypertension secondary to lead exposure, including IEC activities at all levels.

Keywords: Occupational health, Lead toxicity, Hypertension, Anemia

INTRODUCTION

Occupational health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations. Occupational health services means services entrusted with essentially preventive functions and responsible for advising the employer, the workers and their representatives in the undertaking, on the requirements for establishing and maintaining a safe and healthy working environment which facilitate optimal physical and mental health in relation to work, the adaptation of work to the capabilities of workers in the light of their state of physical and mental health.¹ Advising on planning and organization of work and working practices including the design of workplaces and on the evaluation, choice and maintenance of equipment and on substances used at work is also important. In so doing the adaptation of work to the worker is promised.² Occupational hygiene has been defined as the practice of science and art devoted to the identification, evaluation and control of occupational stresses. Among the occupational diseases, diseases due to chemical agents like chemical gases, inorganic and organic dusts, metals and their compounds, chemicals and solvents constitute one important group.³

Lead is an element evidently known and in use for 6000 years by mankind. It is ubiquitous in nature, affects virtually every system in the body. Humans are exposed to lead in numerous products and myriad of pathways. Workers engaged in lead industries like gasoline additives, lead based paints, ceramic glazes, plumbing of pipes are continuously exposed and are at a greater risk of lead toxicity. In humans lead can result in wide range of biological effects depending upon the level in the body and duration of exposure.⁴ WHO and IPCS (International programme on Chemical safety) are concerned about the health hazards on humans and effects of the levels of lead in environment for over past 25 years.⁵ In recent years research efforts are being directed towards evaluation of toxic effects of lead, particularly on human body as to arrive at safe limits of exposure for occupational hazardous heavy metals.⁶ The present study was aimed to emphasize the health profile of workers in a battery factory and with reference to their blood lead levels and correlation with signs and symptoms of lead toxicity.

METHODS

A cross sectional study was carried out for a period of 6 months from August 2016 to February 2017 among the workers working at battery factory in Nellore, Andhra Pradesh. A total of 254 workers including all official staffs and workers, aged between 20 - 60 years in battery factory were included in this study. There were no female workers in this factory. Written informed consent was obtained from all the workers participating in the study. The study was approved by the institutional ethical committee and prior permission from the management of the factory. Based on nature of work; workers were categorized into four sections: with handling raw materials, battery structuring, battery checking, package section and others.

Data collection and occupational history of the study subjects, history of work exposure, work duration, life style habits, risk factors (alcohol, smoking etc), body mass index, was collected by interviewing personally and noted in a separate performa and entered in a Microsoft excel and analyzed. Hygienic habits (nail cutting, weekly head bath etc), PPE usage awareness was noted. General and systemic clinical examination was done on every subject and noted for any signs of lead toxicity (pallor, lead line etc). Visual acuity testing by using snellen's chart was done by ophthalmic technician and audiogram was done on selected subjects by audiometric technician at Narayana medical college, Nellore as per the discretion of the physician.

Blood pressure was recorded using standard WHO guidelines and recordings were noted.⁷ Laboratory

investigations were done on blood sample collected under standard guidelines. Blood urea, S.creatinine levels were estimated at central biochemistry laboratory of Narayana medical college using automated biochemical analyzer [BioRad USA]. Blood lead level estimations were done on study subjects on blood samples collected in separate vacutainers containing reagent. The specimen was sent to secunderabad diagnostic's lab for lead estimation and anodic stripping voltametry [ASV] method was used and lead levels in blood was expressed in units of µg/dl.

Statistical analysis

The data was entered initially in Microsoft excel spread sheet and checked for any mistakes. The data were analyzed by SPSS 12th version. Basic tables were prepared to facilitate presentation. Descriptive type of analysis like mean, standard deviation and tests of significance were employed depending upon the situation. The statistically analyzed material was presented, compared and discussed in relation to other studies available in the literature.

RESULTS

A total of 254 study subjects working in the Battery Factory, Nellore were included and socio demographic data of every subject with respect to age, socio economic status, BMI, risk factors were noted in a separate proforma. Clinical examination (BP, HR, etc.) for all the subjects and necessary laboratory investigations, visual acuity testing and audiogram for selected study subjects were performed and results were noted. All the workers were literate.

Most of the workers were aged between 41-50 years (33.85%) followed in order by 31-40 (30.73%), 51-60 (18.89%) and 21-30 years (16.53%). 81 of the total 254 (31.88%) were working in battery structuring unit. 35 members of 41-50 years of age were in battery checking unit when compared to other age groups who were predominant in battery structuring unit. 51 of study subjects in 41-50 years age group were in indirect exposure group when compared with other age groups who were placed maximally in direct exposure group. The maximum duration of exposure in the factory, among the selected subjects was 30 years in direct exposure group and 26 years in indirectly exposed group [Table 1].

Socio economic status of the subjects were assessed as per according to BG. Prasad Socio economic scale ⁸ and 29.99% of study subjects were in High socio economic status category, 40.15% in Upper middle, 22.83% in Lower middle, 7% were in Upper High and none of study subjects in poor category. As per BMI calculation, 26.77% of study subjects were underweight, 54.33% were normal weight where as 14.17% were pre-Obese and 4.72% were obese [Table- 1].

Table 1: Demographic data of study subjects.

Variables	No	%
Age (in years)		
21-30	42	16.53
31-40	78	30.73
41-50	86	33.85
51-60	48	18.89
Socio economic status		
Type-I (upper high)	18	7.03
Type-II (high)	76	29.99
Type-III (upper middle)	102	40.15
Type-IV (lower middle)	58	22.83
Type-V (poor)	0	0
BMI (kg/m ²)		
Underweight (< 18.50)	68	26.77
Normal (18.50- 24.99)	138	54.33
pre-obese (25-29.99)	36	14.17
Obese (≥ 30)	12	4.72
Risk factors		
Smoking	88	34.65
Alcoholic	44	17.32
Beetelnut chewer	23	9.06
Tobacco chewer	32	12.60

Out of 254 study subjects, audiogram was performed on 20 subjects, peripheral blood smear examination, blood urea, s. creatinine estimation and hemoglobin estimation

was done on 61 subjects. Blood lead (Pb) level estimation was done in 29 subjects. The observations were displayed according to various parameters and contrasted between the exposed and the non-exposed groups in the same study population. In both the groups, each parameter was differentiated between blood levels and induced toxic effects. The nature of occupation of subjects was differentiated as per the work done in the factory. Among the study population, 14.96% were working in handling of raw material, 31.88% in the structuring of battery section, 30.70% in battery checking, 11.82% in packaging section and 27% in other section (office staff and attendee's). The workers those working in raw material handling and battery structuring were grouped as "Direct Occupational Exposure Group" because they have greater chance of exposure to Lead with (119/254) 46.85% of workers and rest (135/254) 53.15% as "Indirect Occupational Exposure Group" [Table-2].

Among the exposed group 39.49% of the workers were exposed to lead for more than 15 years and 60.50% for less than 15 years. Among the indirectly exposed group, 77% of the workers were exposed to lead more than 15 years and 55.77% were for less than 15 years [Figure 1]. As correlation between occupational exposure to lead and infertility was noticed in some of the studies an attempt has been made to know the fertility pattern of this occupational group and hence, family size particulars of every worker in different sections was selected. Among the direct exposed group, one worker with infertility was noticed.

Nature of Occupation	No (%)	21-30	31-40	41-50	51-60	HTN No(%)	Mean SBP (mmhg) ±2S.D	Mean of DBP (mmhg) ±2S.D	Blood lead Level (µg%) Mean±2S.D
Handling of raw materials	38 (14.96)	10	10	14	4	12 (23.52)	131.27± 20.90	81.86±1 0.75	26.2±2.142
Battery structuring	81 (31.88)	14	21	26	20	17 (33.33)	120.68± 21.69	80.79±9 .93	25.3±2.008
Battery checking	78 (30.70)	4	21	35	18	11 (21.56)	124.50± 21.74	78.09±9 .787	24.5±1.741
Packing	30 (11.82)	8	15	5	2	7 (13.72)	121.29± 20.23	77.89±9 .94	22.1±1.422
Others	27 (10.62)	6	11	6	4	4 (7.84)	124.59± 19.32	79.67±8 .16	20.4±1.939
Type of exposure to lead									
Direct exposure	119 (46.85)	24	33	35	27	29 (24.37)	125.97± 20.23	81.32±9 .42	25.26±2.121
Indirect exposure	135 (53.15)	18	45	51	21	19 (14.07)	123.46± 19.54	78.55±9 .14	22.41±1.722

Table 2: Age wise distribution (years) and relation to hypertension.

Among study subjects 20% were hypertensive's, with mean systolic blood pressure 124.46 mm of hg and mean diastolic pressure was 79.66 mm of Hg. Majority of hypertensive's were working in battery structuring unit

(33.33%). The prevalence of lead hypertension was found to be more in the direct exposure group (11%) than in indirect exposure group (7.48%). The proportion of hypertensives was significantly higher in the direct exposure group (P \leq 0.05) [Table-2]. Out of 20 study subjects subjected to audiometric test, 40% of study subjects had noise induced hearing loss, and 75% of them had hearing loss in one of their ears [Figure 2]. Serum creatinine and blood urea levels were estimated in both the groups, however significance was not associated with this [Table 3].



Figure 1: Duartion of lead exposure.



Figure 2: Hearing status of study subjects (n=20). Table 4: Distribution of study subjects by occupation and signs of lead toxicity.

	Occupational group					
Symptoms	Handling raw materials	Battery structuring	Battery checking	Packing	Others	Total
Pallor	6	7	2	1	1	17
Pigmented tongue	0	0	0	0	0	0
Lead line on teeth	1	0	0	0	0	1
Skin rash	0	1	0	0	0	1
Ataxic gait	0	0	1	0	0	1
Waddling gait	0	0	0	0	0	0
Cranial nerve disturbances	0	1	0	0	0	1
Motor disturbances	0	0	0	0	0	0
Meningeal irritation	0	0	0	0	0	0
Convulsions	0	0	0	0	0	0
Factures	0	1	2	1	0	4
Arthritis	3	4	3	5	1	16
Oedema and puffiness of face	1	1	1	3	0	6
Hepatomegaly	1	0	0	0	0	1
Splenomegaly	0	0	0	0	0	0
Lung signs	0	0	0	0	0	0
Eyes (defective vision)	4	8	2	2	10	26

Table 3: Laboratory parameters in study subjects.

Nature of occupation	Hb (gm%) Mean± 2 S.D	Blood Urea (mg%) Mean ±2S.D	S. creatinine (mg %) Mean ±2S.D
Handling of raw materials	13.93±1.01	20.16±6.86	0.7±0.082
Battery structuring	13.38±1.56	22.62±3.02	0.9±0.152
Battery checking	13.61±1.33	19.37±3.79	0.7±0.141
Packing	14.60 ± 1.39	25.24 ± 7.02	0.8±0.133
Others	14.58±0.75 9	20.28±2.98	0.7±0.189

Among the study subjects studied for different signs of lead toxicity, 10.23% had defective vision, 6.29% had arthritis, 6.62% had pallor of conjunctiva, and 2.36% had edema and puffiness of face and one person found with skin rash. Only one individual of machine section presented with a lead line on the gums. Prevalence of pallor was higher in the direct exposure group than that in the indirect exposure group (P ≤ 0.05) and was statistically significant [Table 4]. The distribution of study subjects according to blood haemoglobin levels showed a difference of 1.0gm% in the mean values in the two groups. There was no statistically significant difference observed, when the both groups were compared in their hemoglobin levels. 29% of tested study subjects had microcytic hypochromic anaemia.

	Occupational group					
Signs	Handling Raw materials	Battery structuring	Battery checking	Packing	Others	Total
Anorexia	0	8	17	8	3	36
Nausea	0	3	5	1	0	9
Vomiting	0	0	0	0	0	0
Metallic taste	0	1	1	0	0	2
Abdominal discomfort	0	13	10	7	3	33
Diarrhoea	0	0	2	2	0	4
Constipation	0	0	7	3	2	12
Headache	1	8	20	9	8	46
Arthralgia	7	15	20	13	4	59
Bodyaches	10	14	15	12	б	57
Fatigue	7	10	15	5	7	44
Insomnia	1	10	10	6	3	30
Irritability	4	5	9	8	0	26
Tremors	0	1	3	1	0	5
Dysuria	0	2	1	3	0	6
Loss of cough / cold	2	6	6	9	2	25
Pyrexia of duration	0	1	0	0	0	1

Table 5: Distribution of study subjects by occupation and symptoms of lead toxicity.

Table 6: Distribution of the study subjects by visual acuity and nature of work.

Symptoms	Vision (category of visual impairment)	Occupational group					
		Handling of raw materials	Battery structuring	Battery checking	Packing	Others	
6/6 to≥6/18	Normal	36	78	77	30	24	
<6/18 to≥6/60	Low vision 1	2	4	1	2	3	
<6/60 to ≥3/60	Low vision 2	2	3	1	0	6	
<3/60 to no light perception	Blindness (3,4,5)	0	1	0	0	1	

Various symptoms of lead toxicity in the study subjects are presented in the Table 5. 23.22% of the workers were suffering from arthritis, 22.44% from body aches, 18.11% with headaches, 17.31 with fatigue, 15.34% with loss of weight and 11.81% with insomnia. When the two groups were studied separately, manifestations like arthralgia, fatigue and loss of weight were found to be significantly higher in the direct exposed group than in indirectly exposed group (P ≤ 0.05).

Analysis of blood lead levels in study subjects shows the lead levels were high in those handling raw materials. The mean blood lead values were high in direct exposure group when compared to the indirect exposure group. The difference was not statistically significant. The mean blood lead levels were high in study subjects those handling raw materials. [25.26 \pm 2.121 µg%] According to their blood lead levels, workers of direct exposure group characteristically showed higher prevalence of diastolic and systolic hypertension with higher Pb levels, though statistical significance was not seen. When the two groups were studied separately, there was a difference of 3-4 mmHg, in the mean levels of both systolic and diastolic blood pressure in the direct exposure group.

Table 6 represents the visual acuity results of study subjects exposed directly. 9 persons developed low vision and 2 developed blindness with one in battery structuring unit and 1 in other section. However the loss of vision among study subject in other section was due to uncontrolled glaucoma.

DISCUSSION

Workers working in a battery factory are continuously exposed to regular health risks which significantly affect the health status of the workers. The present study was done to assess the health profile and health hazards of the workers in a battery factory and associated morbidities of the workers faced during the work period. All the workers in the factory were male pointing towards the gender predisposition in the factory which indicates the type of work in the factory. Males are more inclined towards more hazardous and physically challenging works in the factory. The most common age group in the study was 41-50 years and all of the participants were literate educated up to secondary level (10th standard) and most of them were technically trained personnel.

Chemical toxicity mainly exposure to lead was considered as major health hazard in the present study which was mainly focused. Various manifestations of lead toxicity was higher in the direct exposed group compared to indirect exposed group and statistical significance was associated with symptoms like arthralgia, fatigue and loss of weight, and signs like pallor of conjunctiva. Advanced manifestations of lead toxicity like blue line on gums, lead induced hypertension was also observed in the workers depending upon the nature of the work and duration of exposure in the same occupation. So the present study was directed mainly on the estimate of body burden of lead and duration of exposure and not only on blood lead levels. Observations of different studies indicate that occurrence of certain alternations at subcellular level in haemopoitic, renal and nervous system occurs even in normal range of blood lead concentration of $10 - 60 \mu g/dl$. Alauddin et al and Granick et al proved existence of subclinical toxicity of lead on heamopoitic activity was due to ALAD activity inhibition at blood lead level concentrations of 20 - 40 ug/dl.9,10 Few studies reported that Pb concentrations in the range of 0-20 µg/dl as normal and have no toxic effects. The present study revealed that blood lead concentrations in the workers were in the range of 10-29 μ g/dl. Which is on par with findings of Herbert and Hunter et al.^{11,12} WHO (1999) concluded that toxic effects of lead are likely to occur on haemopoitic and nervous system only at levels of more than 60 µg/dl.¹³ Massaro E J, Winder C, U.S.Environmental protection agency (1986) in their study of lead effects on cardiovascular function and Fenga et al indicated that increased blood lead concentration levels are related to increased systolic and diastolic blood pressures.¹⁴⁻¹⁶ The range of blood lead concentration in these studies was more narrow (2-21 µg/dl), compared to other population studies (8-35µg/dl); existence of relation between blood pressure and blood lead concentration was proved. Sharp et al (1988) demonstrated only a small relation between blood pressure and blood lead concentration, which was consistent with other cross-sectional study findings (2.0-2.5 mm of Hg increase for 1 µg/dl).¹⁷ WHO (EHC 165, 1995) task group in their evaluation off risks to human health from exposure to inorganic lead, concluded that lead exposure is associated with a small increase in blood pressure. The findings of the present study suggest that the problem of lead induced hypertension is attributable to increased Pb levels consequent to direct occupational exposure to lead. Our study reveals significant association of lead induced hypertension with certain of the life style risk factors like smoking, alcohol intake and tobacco chewing in the study subjects. This finding concurs with the findings of Grandjean et al, Dongre et al, Alauddin who reported that blood lead concentrations are high in smokers than in the non – smokers.¹⁸⁻²⁰ The results of the present study confirm the existence of lead toxicity and lead induced hypertension in the factory workers, indirectly suggest the need for carrying out systematic screening for various manifestations of lead toxicity.

In our study 40% of study subjects were affected by noise induced hearing loss, out of 20 were examined. A study conducted by National Institute of Occupational Health in thermal power units reveals that deterioration in hearing ability at the higher frequency (3000 - 8000) in both the ears associated with the years of exposure. The noise level from 85 to 97 dBA was observed at different work places. Chronic exposure to lead is associated with significant toxicity which causes damage to gastrointestinal, renal, nervous and hematopoietic systems of workers working in the factory which is evident in the present study and concurs with many of the studies in India and abroad.²¹⁻²⁴

Still the occupational and environmental exposure to lead is on increase in our country due to rapid industrialization and in addition awareness about lead toxicity, its biological effects in the long run and its prevention is lacking. Thus strengthening of IEC activities by health education to individuals, family and community about the various manifestations due to subclinical toxicity of lead and need for provision and procurement of certain personal protection measures for the workers, medical supervision of the workers, personal hygienic behavioral practices by them both at work place as well as in the household, periodic assessment of both blood lead levels and blood ALAD activity and subsequent intervention becomes imperative.²⁵

CONCLUSION

Health hazards due to metals are increasing globally for the past two decades. Heavy metal, lead is a major environmental pollutant and its toxicity continues to create health problems in several segments of the population and in many ways. Hence research efforts are on to develop safer compounds, which can be used in lead toxicity. In addition there is very little information on the biochemical makers reflecting subclinical lead toxicity. There is urgent need for the prevention and control of lead toxicity by strengthening the systematic screening for blood lead levels compatible with sub clinical lead toxicity and a routine case finding for hypertension secondary to lead exposure, including IEC activities at all levels.

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