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International Journal of Collaborative Research on Internal Medicine & Public Health
Vol. 3 No. 2 (February 2011)

Featured Article from IOMC 2011 Conference
http://www.iomcworld.com/2011/

International Journal of Collaborative Research on Internal Medicine & Public Health (IJCRIMPH)

ISSN 1840-4529 | Journal Type: Open Access | Volume 3 Number 2

Journal details including published articles and guidelines for authors can be found at:
http://www.iomcworld.com/ijcrimph/

To cite this Article: Galal S, El-Samra GH, Mazhar M, El-Kholy F, Hegazy A. Risk Behaviour of lead-exposed Workers and Hearing Impairment. *International Journal of Collaborative Research on Internal Medicine & Public Health*. 2011; 3 (2):132-142.

Article URL: http://iomcworld.com/ijcrimph/ijcrimph-v03-n02-02.htm

Correspondence concerning this article should be addressed to Prof. Salma Galal (MD, PhD), Former WHO officer and Professor of Public Health / Medical Sociology; 23, Sh. Abdel Kader Al-Maghrebi 11351 Heliopolis, Cairo, Egypt; Tel: +20 2 26222236 / Email: asra78@gmail.com

Paper publication: 06 April 2011

Risk Behaviour of lead-exposed Workers and Hearing Impairment

Salma Galal (1) [*], Gamal H El-Samra (2), Manal Mazhar (3), Fatma El-Kholy (3), Amel Hegazy (4)

(1) Former WHO officer and Prof. of public health and medical sociology

(2) Department of Industrial Medicine and Occupational Diseases, Cairo University, Egypt

(3) Department of Community and Industrial Medicine, Faculty of Medicine (G), El-Azhar University, Cairo, Egypt

(4) Lecturer of Occupational Health at Department of Community and Industrial Medicine, Faculty of Medicine (G), El-Azhar University, Cairo, Egypt

** Corresponding author; Email: asra78@gmail.com*

ABSTRACT

Background: The widespread use of lead and its components has its hazards and causes health disorders to industrial workers. The hazards are determined by a number of factors e.g. work process, ventilation, general hygienic condition of the workroom and personnel [1], and preventive measures. No prevalence of deafness associate with lead exposed workers was found in Egypt. However, there is an increase in all-cause mortality with high blood lead level.

Aim and objectives: The aims of this study are:

1. To determine the association between elevated blood lead levels and hearing impairment in lead-exposed workers.
2. To investigate the use of preventive measures

Methods and study design: The study was conducted on a random sample of 61 lead-exposed (mean age 40.4 years) and 50 non-exposed male workers (mean age 39.2 years) in printing presses and battery industries in Cairo. Blood lead levels were determined and an audiometric evaluation was done at different frequencies (500-8000 Hz). The use of preventive measures for lead-exposed workers was investigated and regular check-up.

Results/ Findings: The mean blood lead level in the lead-exposed group was 52.5 µg/dl $\pm$ 21.5, and in the non-exposed was 18.2 µg/dl $\pm$ 5.9 (t=10.9 (CI 28.1 – 40.5) p<0.001). There was a significant correlation r=0.7 between blood lead levels and binaural hearing.

The audiometric evaluations revealed significant positive correlation between blood lead level in exposed workers and hearing impairment. All lead exposed workers had hearing impairment at different frequencies. Although all workers were aware of protective devices against lead exposure, 100% of them did not use any. They also did not go to regular checkups.

Study limitations: Researchers could not assess the environmental lead levels in workers' residences.

Conclusions: Hearing impairment in lead-exposed workers in printing presses and battery industries in Cairo is inevitable and irreversible. The mean blood lead level in the lead-exposed group was 52.5µg/dl, and in the non-exposed was 18.2µg/dl. All workers didn't use any protective devices or go to regular checkups.

Keywords: Blood lead, hearing impairment, masculinity, battery industry, print shop

Introduction

The use of lead and its components in diverse industry exposes workers to health disorders. The hazards are determined by work process, ventilation, and hygiene of the workplace and personnel[1]. Besides the worker's educational level and economic conditions, risk behaviour also contributes to the health condition[2] . Lead can contaminate air, water, soil, and food. The main entry paths of inorganic lead into the body are the lungs, mainly, in occupational exposure, and the gastrointestinal tract in non-occupational exposure[3]. The absorbed lead concentrates mostly (90%) in the bones, while the rest remains in the blood, bound to erythrocytes, and in the soft tissue as an exchangeable fraction. Only a small quantity of lead accumulates in the brain, mostly in grey matter, and the basal ganglia. The elimination of lead takes place mainly through the urine (80%)[1].

Lead causes a variety of adverse health effects including gastrointestinal symptoms, central and peripheral nervous system damage, kidney diseases, anaemia, and reproductive abnormalities. "Nervous, gastrointestinal, and musculoskeletal symptoms all began to be increased in individuals with blood leads between 30-39 µg /dL and possibly at levels as low as 25-30 µg /dL for nervous system symptoms"[4].

No prevalence of deafness associate with lead exposed workers was found in Egypt. However, Lustberg and Silberberg[5] found that high blood lead levels had a "46% increase in all-cause mortality" in the US population.

Aim and objectives

The aims of this study are:-

1. To determine the association between elevated blood lead levels and hearing impairment in lead-exposed workers;

2. To investigate the use of preventive measures;

Methods and study design

Subjects

This study was done on a multistage random sample of 61 lead-exposed workers and 50 non-exposed employees in two printing presses and two battery industries in Cairo. Fifty percent of all universities printing presses in Cairo were randomly chosen. All registered battery industries in Cairo were included. Over one third (37%) – making 61 - of the 170 lead-exposed workers in the four sites were randomly selected from administrative files provided they fit the inclusion criteria.

Exposed and non-exposed persons were selected from the same sites according to the following inclusion criteria:

1) Their age ranged between 20-60 years.
2) They were not working in other workshops after work.

Criteria for exclusion from the study were the following:

- Auditory trauma
- Ear discharge
- History of auditory diseases
- Surgical operations of the ear
- Exposure to loud noise
- Intake of ototoxic drugs

Non-exposed staffs were from other departments of the same workshop or industry, were not exposed to lead occupationally, and were similar in age to the exposed workers. Over one-third (37%) of the lead-exposed workers in the four sites were randomly selected as were 37% of the non-exposed staff. However, 17 of the non-exposed staff refused to enter the study and two of the lead-exposed workers were

unwilling to give a blood sample. Taking blood samples from, apparently, healthy individuals outside of health services can be very difficult in Egypt.
All work places worked one shift; 8 hours/days, 6 days/week.
Lead-exposed workers were compared with non-exposed staff.
As many workers had little or no education, all subjects entered the study with their oral informed consent.
The research committee in the faculty approved the research protocol and the ethical issues before starting the study.

Methods

1. All individuals chosen were interviewed using a questionnaire, which included section on characteristics, personal history, occupational history, and noise exposure. Selection / exclusion criteria were included in the questionnaire. In addition, open questions were included in order to have a grasp of their understanding of use or non-use of protective measures during work.

2. A sample of 5-ml whole blood from the ante-cubital vein was withdrawn from each worker to determine the lead levels.
The blood sample was taken from each individual by a disposable syringe, then transferred to glass tubes which contained 2 drops of heparin and was kept in the refrigerator (-5 Cº) until the time of the test.
Determination of blood lead levels was done by the Atomic Absorption Spectrophotometer GBC model 932 equipped with graphite furnace (GF 3000) and an auto-sampler, PAL 3000.

3. Audiometric evaluation performed by a trained audiometric specialist included pure tone audiometry air conduction hearing threshold level for frequencies 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz for both ears. In each of the four sites a quiet room was chosen with noise levels of less than 50 dB. Using noise-excluding headsets, each subject was tested in their work site's quite room. The threshold was taken as the faintest sound to which the subject responded.

4. Hearing loss was calculated according to Niland and Zenz[6].It was taken into consideration that the normal hearing threshold in audio-grams ranged between -10 to +15 dB. Binaural hearing loss was calculated as follows**:**

- The average of the hearing threshold level at frequencies 500, 1000 and 2000 Hz was calculated for each ear, after subtracting 15 dB from each reading.
- Then multiplying the better ear (smaller number) by 5 and the poorer ear (larger number) by 1 and dividing the sum by 6.
- The same formula was used for calculating hearing loss at frequencies 4000, 6000 and 8000 Hz.

5. The noise level was measured in the work places during the shift using Sound Level Meter, Model 452, ANSI Type 2-Scott Instrument laboratories. The mean value of each site was calculated by taking 3 readings (dB) at different working hours. It was found to be less than 85 dB.

Statistical methods

The statistical analysis was performed with SPSS 10 using the 0.05 level of significance and 0.01 for blood lead. Besides descriptive statistics, t-test, chi-square test (chi-sq), logistic regression and crude odd ratio (OR) with 95% confidence interval (CI) were also used.

Results/ Findings

Comparison between lead-exposed and non-exposed workers

Table (1) shows the characteristics of lead-exposed and non-exposed workers with regard to age, residence, marital status, education, and smoking. Both groups were comparable in view of age, residence, marital status and smoking habits. Lead exposed workers had significantly lower educational levels than non-exposed.

Fifty six percent (56%) of the workers had between 15-30 years of lead exposure.

None of the lead exposed workers used protective devices or went to regular checkup.

Correlations between lead levels and hearing loss

A significant positive correlation (r=0.7) was found between binaural hearing loss (dB) at frequencies 500-2000 Hz and blood lead levels, and at frequencies 4000 Hz (r=0.63), 6000 Hz (r= 0.67) and 8000 Hz (r=0.69) ($p<0.05$).

There was no significant correlation between duration of exposure and hearing loss at frequencies 500-2000 Hz and at the different frequencies in the lead-exposed group.

A significant positive correlation (r=0.33, p=0.009) was found between residence and blood lead in cases but not in controls (r=016, p=0.46). Those residing in rural area have significantly higher blood lead than urban area.

Results of blood lead levels in both groups

Table (2) demonstrates distribution of lead-exposed and non-exposed workers according to blood lead level 30-89.9 µg/dL and less than 30 µg/dL. There is a significant difference between lead exposed and non-exposed workers with regards to blood lead levels ($p<0.05$). Twenty three percent (23 %) of lead exposed workers had blood lead levels of less than 30 µg/dL compared to 96 % of non-exposed workers, while 77 % of exposed workers and only 4 % of non-exposed workers had blood lead levels of 30 µg/dl or more. In addition, it was found that the mean blood lead level among lead-exposed workers was 52.5 µg/dL ±21.5 (range 17.2 – 89.8 µg/dL) compared to 18.2 µg/dL ±5.9 (range 8.2 – 31.8 µg/dL) for the non-exposed group ($p<0.05$).

Table (3) illustrates that the lead exposed workers had significantly higher binaural hearing impairment at 4000 Hz, 6000 Hz and 8000 Hz than the non-exposed workers ($p<0.05$).

Table (4) regarding loss of hearing shows a significant difference between lead exposed workers with blood lead levels of less than 30 µg/dl and those with blood lead levels of 30 µg/dl and more as regards hearing loss (dB) at frequencies 500-2000 Hz and at frequencies 4000 Hz, 6000 Hz and 8000 Hz ($p<0.05$).

Logistic regression analysis

Table (5) demonstrates logistic regression of the most relevant variables affecting hearing loss. It was apparent that the blood lead level was the most important predictive risk factor affecting hearing loss at frequency 500-2000 Hz ($p<0.00$) followed by age ($p<0.02$) with odds ratio 1.137, and 1.094 respectively. Duration of occupational lead exposure and number of cigarette smoking had no significant effect ($p>0.05$). Similar findings were made for frequency 4000 Hz., while at frequency 8000 Hz only blood lead levels had the most marked effect on hearing loss.

Discussion

Lead and its compounds can cause a variety of unfavourable health effects. A small number of studies on humans have shown evidence that lead may cause sensory-neural hearing loss[7].

Our Stud; Level of lead in the blood

In this study, the mean blood lead levels were significantly higher in the exposed group than the control group. Worker lead should not exceed 30µg/dL[8]. It is possible that they were

exposed to additional environmental lead such as gasoline lead before the 1995 Egyptian regulations on gasoline free lead. Farahat et al reported[9] lower mean values of blood lead level in exposed and non-exposed workers (36.94 ± 4.36, and 11.51 ± 1.22 μg/dL respectively) in Egypt. This difference is probably due to a difference in measurement methods and /or the oldness of the study. The variation in the biological level of blood lead is attributed to individual differences in the sensitivity to the chemical or in its rate of absorption, distribution, bio-transformation, excretion and exposure period.

Hearing impairment

The lead-exposed group had significantly higher hearing impairment at frequencies 4000 Hz, 6000 Hz, 8000 Hz than the non-exposed group. Comparing subjects at different frequency levels, no difference was found with regards to age, duration of lead exposure or smoking.

Chuang et al[7] found a dose-response relationship between blood lead and hearing thresholds. We found the hearing impairment to increase as the blood lead levels increased.

In our study, there is a significant positive correlation between hearing loss and blood lead level in exposed workers at frequencies 500-2000 Hz and at frequencies 4000, 6000 and 8000 Hz respectively.

Possible mechanism of hearing impairment after lead exposure

Chuang et al reported[7] that there is a significant correlation between blood lead level and an elevated hearing threshold at 4000 Hz. Hotta *et al*.[10] reported that although the sensory cells of the inner ear appeared to be normal, the acoustic nerve showed axonal degeneration and segmental demyelination in lead-exposed workers. Therefore, lead exposure was not considered to induce a dysfunction in the organ of Corti. Lead reduced nerve conduction velocity and altered myelination. Its toxicity probably takes place at the axonal nodes.[11]

Other factors associated to hearing impairment

Age and noise also affect the hearing threshold[12]. It is possible that blood lead levels and age interact together, as noise as a factor was excluded in this study being that there was less than 85 dB at the work place. However, noise in the living environment was not something we had control over. The limitation of this study was measuring noise levels at home. Since exposed workers and non-exposed employees lived scattered in different areas in- and outside Cairo, this could not be assessed. In this study, blood lead levels and age were found to be the most significant factors in affecting hearing at frequencies 500-2000 Hz, at frequency 4000 Hz, 6000 Hz and 8000 Hz.

Risk behavior contributing to hearing impairment

Although protective devices against lead exposure exist - masks, overalls, gloves and adequate respiratory protection[13]- workers found it 'unmanly' to use them. The use of protective devices does not agree with their conception of 'manhood' or masculinity. All workers (100%) were engaged in risk behavior and did not use protective devices thereby jeopardizing their health[2]. It was not possible to compare them with other using protective devices. They did not go to regular check-ups for lead levels or hearing.

It is recommended, that pre-placement, periodic blood lead examinations and audiometric evaluation should be carried out for lead-exposed workers. Blood lead examinations must be carried out at least every six months[14] . Also regular control of absolute neutrophile count (ANC) is suggested.[15] Workers dealing with lead should be given selenium as it seems to aid in protecting auditory function[7]. Workers with

high lead levels need to be rehabilitated. In addition, constant supervision is needed to ensure proper use of preventive measures, and to give workers continuous health education.

Study limitations

Researchers could not assess the environmental lead levels in workers' residences.

Conclusions

Workers exposed to lead in print shops and the battery industry become hearing impaired. Protective devices are not used and regular hearing and lead levels check-ups are not done. Hearing impairment goes unnoticed but is a permanent disability and irreversible. Therefore, strict preventive and control measures should be taken at the work place and lead and hearing check-ups should be done regularly.
An intervention study is needed to find the best way to convince workers to use protective measures.

Acknowledgement

The authors thank Dr. A W Smith at WHO Geneva and Prof. O. Galal at King Fahd Medical City / Riyadh for peer reviewing this article.

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Table 1: Characteristics of lead exposed and non-exposed workers according to age, residence, marital status, education, smoking and duration of exposure

Variables	Lead-exposed N = 61		Non-exposed N = 50		Chi- square (or adjusted)	P
	N	%	N	%		
Age (years)						
20-29	10	16.4	14	28.0	2.94	>0.05
30-39	17	27.9	10	20.0		
40-49	25	41.0	17	34.0		
50-59	9	14.8	9	18.0		
Residence						
Urban	51	83.6	48	96.0	3.19	>0.05
Rural	10	16.4	2	4.0		
Marital status						
Married	51	83.6	37	74.0	2.34	>0.05
Single	10	16.4	12	24.0		
Widowed	0	0.0	1	2.0		
Educational levels						
Illiterate, read & write	37	27.8	0	0.0	17.68*	<0.05
Primary & preparatory	32	52.5	31	62.0		
Secondary & university	12	19.6	19	38.0		
Smoking						
Smoker	35	57.4	24	48.0	0.97	>0.05
Non-smoker	26	42.6	26	52.0		
Duration of lead-exposure						
	N	%				
0-5 years	7	11.4	-	-		
6-10	11	18.0	-	-		
11-15	8	13.1	-	-		
16-20	26	42.6	-	-		
21-30	9	14.7	-	-		

*significant difference

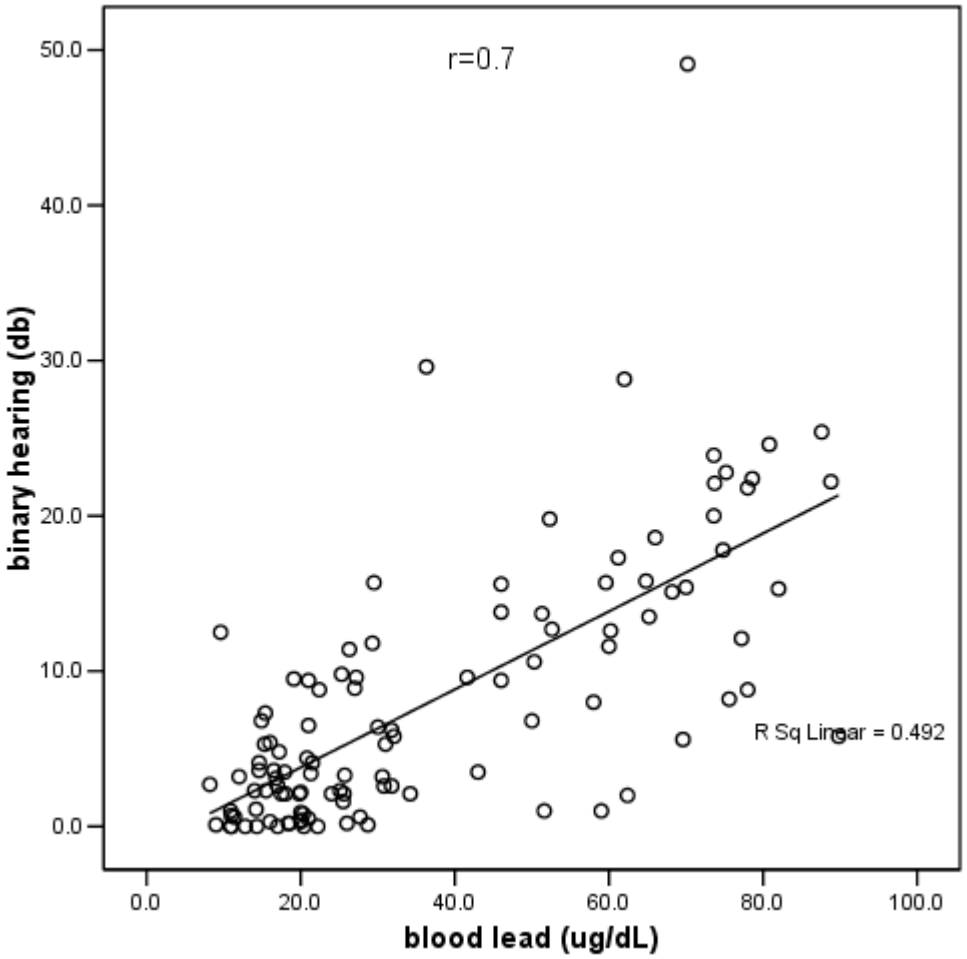

Figure 1: Correlation (r=0.7) between blood lead levels and binaural hearing

Table 2: Distribution of lead-exposed and non-exposed workers according to blood lead level; less than 30 µg/dl and 30-89.9 µg/dl

Blood lead µg/dl	Lead-exposed workers N = 61		Non-exposed workers N = 50		Chi-square	p
	N	%	N	%		
<30	14	23.0	48	96.0	56.54	<0.05
30-89.9	47	77.0	2	4.0		
Total	**mean 52.5 µg/dl ±21.5**		**mean 18.2 µg/dl ±5.9**			

p<0.05 = significant difference

Table 3: Mean and standard deviation of hearing loss (dB) at different frequencies among studied groups

Hearing loss at different frequencies (Hz)	Lead-exposed N= 61 Mean (dB) ± SD	Non-exposed N= 50 Mean (dB) ± SD	t test	p
500 - 2000	12.7 ± 8.86	2.45 ± 2.54	62.6	<0.05
4000	17.52 ± 12.48	1.31 ± 2.2	82.14	<0.05
6000	9.67 ± 10.84	0.72 ± 1.65	33.36	<0.05
8000	16.16 ± 14.17	0.88 ± 1.53	119.5	<0.05

p<0.05 = significant difference

Table 4: Mean and standard deviation of hearing loss (dB) at different frequencies for lead-exposed workers with blood lead levels of 30 µg/dl and more compared with those of less than 30 µg/dl

Hearing loss at different frequencies (Hz)	Blood lead ≥30µg/dl Mean (dB) ± SD	Blood lead <30µg/dl Mean (dB) ± SD	t-test	p
500- 2000	14.21 ± 9.32	7.67 ± 4.48	6.38	<0.05
4000	19.77 ± 13.08	9.97 ± 5.77	7.34	<0.05
6000	11.90 ± 11.35	2.19 ± 2.88	9.93	<0.05
8000	18.77 ± 15.05	7.41 ± 4.19	7.70	<0.05

p<0.05 = significant difference

Table 5: Logistic regression of variables affecting hearing loss at frequency 500-2000 Hz

Variables	β	p	Odds ratio (CI 95%)
Blood lead level	0.129	0.0003	1.137 (0.91-1.36)
Age	0.090	0.023	1.094 (0.78-1.41)
Duration of lead exposure	0.029	0.474	0.972 (0.56-1.38)
Number of cigarette Smoking	0.018	0.476	1.018 (0.49-1.54)
Constant	-4.714	0.006	