# Assessment of Blood Lead and Its Determinants among Cables Industry Workers at 10th of Ramadan City in Egypt

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## ABSTRACT

**Background:** Lead poisoning remains a major occupational health problem, especially in developing countries which lack strict legislations for protection of health of workers. **Objective:** This study was conducted among cable industry workers aiming to assess blood lead level (BLL) of lead exposed workers and to determine the associated occupational risk factors of elevated blood lead. **Subjects and methods:** A cross sectional study was conducted among 170 cable industry workers at 10th of Ramadan City in Egypt during the period from July 2022 to June 2023, using a semi structured questionnaire assessing present history of lead toxicity symptoms and by investigating BLL.

**Results:** The current study showed that (80 %) of cable workers had elevated BLL, and reported lead toxicity symptoms as (10%) suffered irritability and nervousness, (9.4%) memory problems, (9.4 %) tingling or numbness in extremities, (5.3 %) difficult concentration, (6.5 %) abdominal pain, (3.5%) constipation and (8.8 %) muscle pain. By regression analysis, the study indicated that, current occupation, previous occupational exposure and gown nonuse were the significant predictors of occurrence of current high BLL. **Conclusion:** Implementation of engineering control measures, ensuring continuous availability of properly designed personal protective equipment (PPE) with applying health education programs for workers about occupational health hazards and preventive measures are recommended.

**Keywords**: Blood lead, Cable industry, Lead toxicity, Symptoms, 10th of Ramadan, Cable workers.

## INTRODUCTION

The element lead is essential to life on Earth. Lead, which can be found in both the ground and the air, has a long history of being one of humanity's most important metals. Lead was originally a waste product from the silver industry, but due to its many useful properties (including low melting point, malleability, and resistance to corrosion), it quickly gained widespread popularity. The Egyptians fashioned sculptures out of lead and used sinkers made of lead to catch fish. The Romans employed substantial quantities of lead for a variety of purposes, including the lining of water supply pipes and cisterns, roofing, shipbuilding, weights, cooking pots, and wine sweeteners. Lead poisoning was therefore widespread in Roman society. Despite the fact that much has been learned about lead and its negative consequences, exposure to lead continues to be a major problem in the modern world. Once lead has been extracted from its ore, it cannot be destroyed or returned to its natural state (although it can be recycled and reused). The vast majority of lead dust on the soil's surface will still be there 70 to 200 years from now [(1)].

About one million people worldwide succumb to lead poisoning every year. In addition, millions more, including many youngsters, are exposed to low amounts of lead, which can have lasting effects [(2)]. Long-term effects of lead exposure are expected to cause 21.7 million DALYs (disability-adjusted life years) of disability and death worldwide [(2)]. Every single human organ can be negatively impacted by lead exposure. Lead intoxication can have an adverse effect on nearly every bodily process [(3)].

Lead toxicity primarily affects the neurological system rather than other organs. Adults who are exposed for an extended period of time may score lower on assessments of cognitive functioning and neuropsychological testing. Young children and infants are more vulnerable to the effects of lead exposure, which can include behavioral issues, learning difficulties, and a reduced IQ. Anemia and hypertension have both been linked to prolonged lead exposure, especially in the elderly and the middle-aged. Exposure to high amounts of lead was associated with fatal brain and kidney damage in both adults and children. An increased risk of miscarriage has been linked to lead exposure during pregnancy. Male fertility is decreased by prolonged lead exposure. Lead intoxication frequently results in blood problems and nervous system damage [(3)]

Lead exposure is linked to an increased risk of developing idiopathic intellectual disability (30%), cardiovascular disease (4.6%), and chronic renal disease (3%), according to the World Health Organization. Everyone with a blood lead level higher than 5 ug/dl should take steps to identify the source of lead exposure and take measures to decrease and terminate exposure, as recommended by the World Health Organization. Lead exposure of any kind is harmful [(2).]

Leaded gasoline, industrial operations like smelting of lead and its combustion, pottery, boat building, lead based painting, lead containing pipelines, printing books are only a few of the many sources of lead and its compounds to which humans are exposed through their work. In addition, lead is currently employed in a variety of applications, including construction, cable sheathing, radiation shielding, and alloys. It is utilized as a powder in a wide variety of applications, including pigments, paste, glass, glazes, and functional ceramics [(3)].



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Its key qualities, including as softness, malleability, ductility, poor conductibility, and resistance to corrosion, mean that it is still utilized in developing countries despite its broad decline in use elsewhere. It seems to make it hard to abstain from its use [(4)].

The cable sector is one of the most dangerous because of the frequent exposure of workers to lead. Even while clinically overt lead poisoning is uncommon among these occupational groups, those who work with cables have a higher-than-average rate of lead-associated central nervous system symptoms (24%) [(5)]. Because of the significance of BLL and the negative health effects of lead exposure on cable workers, this research is crucial as it aims to assess blood lead level of workers in cable industry and to determine the associated occupational risk factors of elevated blood lead [(5)] .

## SUBJECTS AND METHODS

Workers at two cable industry factories in 10th of Ramadan city, Sharkia Governorate, Egypt, were surveyed in a cross-sectional study conducted from July 2022 to June 2023.

The following information was used in Open-Epi version 3.01 to determine the sample size: There were a total of 2359 people employed in the cable business; about 13.8% of these people suffer from occupational asthma [(6)]; confidence level = 95%; confidence limits = 5%. There were 170 total employees used as a sample.

**Sample selection**: From total 7 cable industry plants at 10th of Ramadan city, two plants were selected randomly by simple random, and the number of workers in 1st plant was 350 while the number in 2nd plant was 170, so the number of selected workers was taken from each plant according to proportional allocation (2:1) >{ 113 from 1st plant, 57 from 2nd plant} and workers from each plant were selected randomly from the sampling frame (using workers' list at each workplace) by simple random technique.

In order to assess the response to different elements of the questionnaire, the feasibility of the study, and to highlight the hurdles that may develop during data collection, a pilot study was conducted utilizing the semi-structured questionnaire on 10% of the sample who were excluded from the sample. No mention was made of the pilot study's findings in the main findings. The pilot study's findings informed several changes to the questionnaire, such as shortening the questions to improve their readability and eliminating inquiries concerning the frequency and severity of symptoms because majority of the pilot study's participants were unable to answer those questions.

Workers who were involved in the process and exposed to its hazards and were willing to participate in the study met the inclusion criteria.

Exclusion criteria were as follows: Workers in the administrative sector who are not directly involved in the process and employees flat-out declined to take part in the research.

**Data collection tools**

Each participant filled out a pre-formatted questionnaire that asked them to provide details on the following areas of interest:

Information about yourself, such as your age, education, address, marital status, and smoking habits. Involved smoking behaviors were: Cigarettes: daily count, daily pack count, length of smoking history, and length of time since quitting if applicable. If the employee smokes shisha, how often (daily, weekly, annually) and for how long (in years) they do so.

Work experience, which included today's workforce has been segmented into subsets based on where in the process they now sit; Copper rods are drawn too thick to be used in flexible wires without first being thinned down. Flexibility can be increased by stranding insulated cables or wires together. Insulation: the bare copper wires are insulated and cable sheathing for various uses, often known as cabling. Time spent in current occupation, Average daily hours worked, Previous occupation, Time spent in previous occupation, Access to environmental monitoring, Access to natural ventilation at workplace, Access to air purification methods at workplace, Opinion on workplace ventilation, Pre-employment medical examination results, Job performance If not, please explain why.

**Symptoms of chronic lead toxicity:** Symptoms of lead toxicity that are being asked about include: abdominal pain, constipation, metallic taste, irritability or nervousness, memory issues, difficult concentration, sleep problems, depression, headache, tingling or numbness in extremities, and muscle pain. It was originally written in English and then translated into Arabic, where it underwent validation via back translation and preliminary testing.

**Blood lead level:** Value of (5 microgram per decilitre or more) was considered as cut off to be high level according to CDC [(7)].

The pre-designed questionnaire was reviewed by a panel of occupational medicine experts for content language clarity, relevancy, readability, ease of understanding, question sequence, and completion time. It was also tested multiple times to test the reliability and calculate the reliability coefficients (Cronbach's alpha), which were generally high (0.78) for all questionnaire parts, and suitable for scientific purposes.

**Ethical considerations**: **The Research Ethics Committee of Zagazig University's School of Medicine gave its stamp of approval to the study's methodology. Managers of cable industry facilities gave their verbal approval for the research to be conducted. Both privacy and confidentiality were upheld. All those who took part in the study gave**

**their informed consent. Participants were advised that the information they provided would be utilized purely for scientific research. Participants had also the opportunity to opt out of the study entirely if they so desired. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**

**Data management:**

SPSS (Statistical Package for the Social Sciences) version 26.0 was used to enter, check, and statistically analyze the obtained data. Frequencies and percentages were used to depict the qualitative data. The mean and standard deviation were used to represent numerical data. The median and range were used to present the nonparametric data. The median and range were used to characterize daily cigarette consumption and cumulative smoking time. Univariate analysis was used to determine the connection between selected sociodemographic, smoking, and occupational factors and the detected problems among the workers by calculating odds ratios (OR) and their 95% confidence intervals (95% CIs). Predictors of each outcome were determined using a binary logistic regression analysis. If the p-value was less than 0.05, it was considered meaningful; if it was less than 0.01, it was highly noteworthy.

## RESULTS

**Table (1)** shows the sociodemographic and occupational characteristics of the studied workers.

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**Table (1): Frequency distribution of sociodemographic and occupational characteristics of the studied workers**

| | Variable | NO | % |
|---|---|---|---|
| **Age (by years)** | **(mean ± SD)** | **(36.31 ± 9.47)** | |
| | ▪ 20- | 43 | 25.3 |
| | ▪ 30- | 70 | 41.2 |
| | ▪ 40+ | 57 | 33.5 |
| **Residence:** | ▪ Rural | 98 | 57.6 |
| | ▪ Urban | 72 | 42.4 |
| **Marital status:** | ▪ Married | 140 | 82.4 |
| | ▪ Unmarried | 30 | 17.6 |
| **Education:**<br>▪ **Diploma levels:** | ▪ High =60<br>▪ Middle= 110 | 170 | 100.0 |
| | **Smoking:** | | |
| | ▪ Yes | 67 | 39.4 |
| | ▪ No | 103 | 60.6 |
| **No. of cigarettes smoked /day** | **Median (Min-Max)** | 15 (1- 40) | |
| | ▪ < 1 pack | 35 | 52.2 |
| | ▪ 1+ | 32 | 47.8 |
| **Duration of smoking (by years)** | **Median (Min-Max)** | 12 (1- 48) | |
| | ▪ < 10 | 16 | 23.9 |
| | ▪ 10+ | 51 | 76.11 |
| **Current occupation** | Drawing | 75 | 44.1 |
| | Stranding | 20 | 11.8 |
| | Insulation | 54 | 31.8 |
| | Cabling | 21 | 12.3 |
| **No. of years employed in current occupation** | ▪ < 5 | 20 | 11.8 |
| | ▪ 5 - | 49 | 28.8 |
| | ▪ 10 + | 101 | 59.4 |
| **Previous occupation** | NO | | |
| | YES | 74 | 43.5 |
| | | 96 | 56.5 |
| | The following categories; | | |
| | ✚ Battery manufacturing | 51 | 53.1 |
| | ✚ Welding | 33 | 34.4 |
| | ✚ construction | 12 | 12.5 |
| **Duration of previous occupation in years** | < 10 | 79 | 81.8 |
| | 10 + | 17 | 18.2 |
| **Availability of rest places away from exposure** | | 148 | 87.1 |
| **Available workplace ventilation** | | 124 | 72..9 |
| **Air purifying methods available** | | 124 | 72.9 |

Regarding lead toxicity symptoms **(Table 2)**, the most common symptom was irritability and nervousness. As regard blood lead level, (80%) of studied workers had high level of lead in blood of (≥ 5 µg/dl).

**Table (2): Frequency distribution regarding lead toxicity symptoms and blood lead level among studied workers**

| Variable | NO | % |
|---|---|---|
| **Abdominal pain** | **11** | **6.5** |
| **Constipation** | **6** | **3.5** |
| **Irritability and nervousness** | **17** | **10.0** |
| **Memory problems** | **16** | **9.4** |
| **Difficult concentration** | **9** | **5.3** |
| **Tingling or numbness in extremities** | **16** | **9.4** |
| **Muscle pain** | **15** | **8.8** |
| **More than 1 symptom: -** | | |
| ▪ **No symptoms** | **120** | **70.6** |
| ▪ **More than 1 symptom** | **29** | **17.1** |
| **Blood lead levels** | | |
| ▪ **< 5** | **34** | **20.0** |
| ▪ **5-** | **40** | **23.5** |
| ▪ **10-** | **50** | **29.4** |
| ▪ **20-** | **38** | **22.4** |
| ▪ **40-60** | **8** | **4.7** |

As regard relation between high blood lead level and sociodemographic characteristics; **(Table 3)** shows that factors significantly related to high blood lead were age and rural residence.

**Table (3): Relation between high blood lead level** and **sociodemographic characteristics**

| Variable | Positive N=(136) | | Negative N=(34) | | COR (95% CI) | P value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| **Age Categories** | | | | | | |
| ▪ **20-** | **32** | **74.4** | **11** | **25.6** | | |
| ▪ **30-** | **52** | **74.3** | **18** | **25.7** | **0.99 (.4 -2.3)** | **0.987** |
| ▪ **40+** | **52** | **91.2** | **5** | **8.8** | **3.57 (1.13 -11.2)** | **0.023** |
| **Residence:** | | | | | | |
| ▪ Rural | **88** | **89.8** | **10** | **10.2** | **4.4 (1.9-9.9)** | **<0.001** |
| ▪ Urban | **48** | **66.7** | **24** | **33.3** | | |
| **smoking** | | | | | | |
| ▪ yes | **53** | **79.1** | **14** | **20.9** | **1.09 (.5-2.3)** | **0.814** |
| ▪ no | **83** | **80.6** | **20** | **19.4** | | |
| **No of cigarettes smoked /day (in packs)** | | | | | | |
| ▪ **< 1** | **25** | **71.4** | **10** | **28.6** | **2.8 (.77-10.05)** | **0.106** |
| ▪ **1+** | **28** | **87.5** | **4** | **12.5** | | |
| **Duration of smoking in years** | | | | | | |
| ▪ **< 10** | **13** | **81.2** | **3** | **18.8** | **0.8 (.2-3.4)** | **0.809** |
| ▪ **10+** | **40** | **78.4** | **11** | **21.6** | | |

As regard relation between high blood lead level and occupational history **(Table 4),** factors significantly related to high blood lead were current occupation, previous occupation, unavailable workplace ventilation and air purifying methods, mask and gown nonuse.

**Table (4): Relation between high blood lead level and occupational history**

| Variable | Positive N= (136) | | Negative N= (34) | | COR (95% CI) | P-value |
|---|---|---|---|---|---|---|
| | N | % | N | % | | |
| **Current occupation** | | | | | | |
| ▪ Drawing | 71 | 94.7 | 4 | 5.3 | 19.5(5.2 -73.2) | <0.001 |
| ▪ Stranding | 18 | 90.0 | 2 | 10.0 | 9.9(1.8-53.8) | 0.003 |
| ▪ Insulation | 37 | 68.5 | 17 | 31.5 | 2.3 (.8-6.7) | .092 |
| ▪ Cabling | 10 | 47.6 | 11 | 52.4 | 1.0 | |
| **No. of years employed in current occupation** | | | | | | |
| ▪ < 5 | 13 | 65.0 | 7 | 35.0 | 1.0 | |
| ▪ 5 – | 36 | 73.5 | 13 | 26.5 | 1.49(.48-4.5) | 0.481 |
| ▪ 10 + | 87 | 86.1 | 14 | 13.9 | 3.3(1.13-9.8) | .061 |
| **Previous occupation** | | | | | | |
| ▪ NO | 44 | 59.5 | 30 | 40.5 | 15.6 (5.2-47.2) | .000 |
| ▪ YES | 92 | 95.8 | 4 | 4.2 | | |
| **Duration of previous occupation** | | | | | | |
| ▪ < 10 | 75 | 94.9 | 4 | 5.1 | Undefined | 1.0 |
| ▪ 10 + | 17 | 100.0 | 0 | 0.0 | | |
| **No. of work hours/day in current occupation** | | | | | | |
| ▪ 8 hours/day | 136 | 80.0 | 34 | 20.0 | - | - |
| **Rest time available** | 136 | 80.0 | 34 | 20.0 | - | - |
| **Rest places away from exposure** | | | | | | |
| ▪ Yes | 119 | 80.4 | 29 | 19.6 | 0.8 (.2-2.4) | .732 |
| ▪ No | 17 | 77.2 | 5 | 22.7 | | |
| **Environmental monitoring** | 136 | 80.0 | 34 | 20.0 | - | - |
| **Available workplace ventilation** | | | | | | |
| ▪ Yes | 105 | 84.7 | 19 | 15.3 | .3 (.17- .8) | .012 |
| ▪ No | 31 | 67.3 | 15 | 32.6 | | |
| **Available air purifying methods** | | | | | | |
| ▪ Yes | 105 | 84.7 | 19 | 15.3 | .3 (.17- .8) | .012 |
| ▪ No | 31 | 67.3 | 15 | 32.6 | | |
| **Pre employment examination** | 136 | 80.0 | 34 | 20.0 | - | - |
| **Periodic examination** | 136 | 80.0 | 34 | 20.0 | - | - |
| **Head helmet use** | | | | | | |
| ▪ Yes | 121 | 79.1 | 32 | 20.9 | 1.9 (.4-9.1) | .371 |
| ▪ No | 15 | 88.2 | 2 | 11.7 | | |
| **Mask use** | | | | | | |
| ▪ Yes | 49 | 70.0 | 21 | 30.0 | 2.8 (1.3-6.2) | .006 |
| ▪ No | 87 | 87 | 13 | 13 | | |
| **Gloves use** | | | | | | |
| ▪ Yes | 109 | 80.1 | 27 | 19.9 | .9(.37-2.4) | .924 |
| ▪ No | 27 | 79.4 | 7 | 20.5 | | |
| **Gown use** | | | | | | |
| ▪ Yes | 37 | 69.8 | 16 | 30.2 | 2.3(1.09-5.1) | .025 |
| ▪ No | 99 | 84.6 | 18 | 15.3 | | |
| **Goggles use** | | | | | | |
| ▪ Yes | 89 | 76.7 | 27 | 23.3 | 2.03(.8-5.02) | .118 |
| ▪ No | 47 | 87.03 | 7 | 12.96 | | |
| **Ear plugs** and **muffs use** | | | | | | |
| ▪ Yes | 116 | 80.6 | 28 | 19.4 | 0.8(.29-2.19) | .670 |
| ▪ No | 20 | 76.9 | 6 | 23.07 | | |
| **Safety shoes use** | 136 | 80.0 | 34 | 20.0 | - | - |
| **Cause if not used** | | | | | | |
| ▪ Not available | 31 | 75.6 | 10 | 24.4 | 1.4(.6-3.2) | .420 |
| ▪ Cause discomfort | 105 | 81.4 | 24 | 18.6 | | |

By logistic regression analysis **(Table 5),** the significant predictors of high blood lead level among studied workers were current occupation, previous occupation and gown nonuse.

**Table (5): Binary forward logistic regression analysis for the significant predictors of high blood lead level among studied workers**

| Variables | B | S.E. | Wald | OR (CI 95%) | P-value |
|---|---|---|---|---|---|
| **Current occupation:** | | | | | |
| ▪ Drawing | | | **15.477** | | **0.001** |
| ▪ Stranding | **2.184** | **0.740** | **8.716** | **8.881** | **.003** |
| ▪ Insulation | **1.790** | **0.967** | **3.429** | **5.988** | **.064** |
| ▪ Cabling | **-0.129** | **0.631** | **.042** | **0.879** | **.838** |
| **Previous occupation** | **2.739** | **0.636** | **18.534** | **15.469** | **.000** |
| **Gown nonuse** | **1.182** | **.515** | **5.261** | **3.262** | **.022** |

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## DISCUSSION

The largest burden of lead poisoning has been attributed to occupational exposures especially industries like cable industry, which is considered a hazardous occupation that expose its workers to high lead levels, but there is scarcity of research about it so this study is important to determine the prevalence of high BLL among cable industry workers.

In our study, as regard lead toxicity symptoms, workers experienced some gastrointestinal (GIT) and central nervous system (CNS) manifestations; (6.5%) reported abdominal pain, (3.5%) constipation, (10%) irritability and nervousness, (9.4%) memory problems, (5.3%) difficult concentration, (9.4%) tingling or numbness in extremities and (8.8%) muscle pain.

That in comparison with previous research[9] , which revealed that lead exposed workers reported higher prevalence of GIT and CNS symptoms as reported; (36%) suffered abdominal colic, (30%) constipation, (54%) nervousness, (42%) muscle ache and (56%) lack in concentration**.** Whereas workers at battery factory exposed to lead reported mild abdominal pain (56.6%), (11.3%) constipation, (58.5%) metallic taste, (39.6%) nausea, (13.2%) vomiting, (34%) myalgia and (50.9%) numbness in extremities.

An extremely common symptom in battery workers was abdominal pain as (95%) of workers directly exposed to lead reported abdominal pain **[(8)]**. Furthermore, industrial workers with high blood lead (mean: 77.5 $\pm$ 42.8 µg/dL) reported (15%) abdominal pain, (15%) nausea and vomiting, (26%) headache, (28%) muscular symptoms, (21%) irritability, (10%) memory disturbances, (14%) insomnia and (18%) fatigue **[(9)]**. However, **Hwang *et al*. [(10)]** reported that the most common symptom among lead-exposed workers was weakness and fatigue, while the least common symptom was abdominal pain that came and went, and that there was no positive correlation between blood lead levels and the gastrointestinal, neuromuscular, or constitutional groups of symptoms.

Previous research comparing two groups of cable workers with low lead exposure found that the prevalence of CNS and GIT symptoms was 29% and 21% in cable splicers and 24% and 7% in cable producers, respectively. The research concluded that there was no partial relationship among symptoms and BLL **[(5)]**.

In present report we found (80%) of studied workers had high BLL, which is in consistence with a previous study that revealed that (85%) of lead exposed battery workers had raised BLL with mean of (60.45 $\pm$ 14.54 µg/dL) In comparison to control group with lead level found to be less (15.47µg/dL) **[(8)]**.

As regard sociodemographic and occupational characteristics, mean age of studied workers at cable factory was (36.3 $\pm$ 9.47), which is nearly in agreement with **Hakim S [(11)]** who stated that mean age of workers at cable factory was (34.5 $\pm$ 9.30) and **Attarchi *et al*. [(6)]** stated that workers of cable manufacturing company mean age was (38.5 $\pm$ 4.72). In comparison with a previous study where mean age of cable splicers was (30.3 $\pm$ 5.4) and cable manufacturers mean age was (41.0 $\pm$ 11.8) **[(5)].**

All of our studied workers (100%) had education level diploma as this is the common level of education of this working community. In comparison with a previous study where (37.7%) of cable factory workers completed primary school, (28.7%) higher school, (21.3%) don't read or write and the other (12.3%) had university education **Hakim S [(11)]** **and Mostafa *et al*. [(12]** who stated that Egyptian workers at factory of same exposure to high lead levels; (90%) were educated otherwise (10%) were not educated.

39.4% of our studied workers were smokers. In comparison with workers at cable manufacturing company where smokers were (21.3%) **[(6)].** However**, Mostafa *et al*. [(12)]** reported exposed workers at same exposure factory where smokers were (34%).

Most workers were of 2 categories of current occupation (Drawing and insulation) by (44.1%, 31.8% respectively) as the number of workers required for these 2 steps of the process is larger than other steps. Number of years employed in current occupation (10 years or more) was (59.4%), and all of them worked 8 hours per day, which is in concordance with **Basit *et al*. [(8)]** who stated that (74%) of factory workers had job duration of (10-15 years) with chronic lead exposure and **Mostafa *et al*. [(12)]** stated that all workers worked 8 hours daily for 6 days/week with total work duration ranged (2-35 years). Also, the same working hours were reported by **Hakim S** [11] as mean working hours/day were 7.89 $\pm$ 0.61. While, **Attarchi *et al*.** [6] reported that duration of work of workers of cable company ranged (1-23 years).

All studied workers reported pre-employment examination (PEE) and periodic examination in comparison with a previous study at cable factory stated that only (43.4%) of workers had PEE and only (16.4%) had periodic examination **Hakim S** [11].

Studied workers reported wearing different types of personal protective equipment (PPE) including (Head helmet, mask, gloves, gown, goggles, earplugs and muffs, safety shoes) by the following prevalence respectively (90%, 41.2%, 80%, 31.2%, 68.2%, 84.7%, 100%), which in comparison with a previous study reported factory workers of same exposure to high noise and lead levels used (gloves, mask, uniform, boots) as (60%, 56%, 56%, 26%) respectively [12]. Whereas another study at cable factory reported that (18.9%) of workers were using PPE **Hakim S** [11]**.**

As regard cause of non-regular using PPE, (75.9%) of workers reported that their use causing annoying and discomfort and (24.1%) reported that PPE is not always available at workplace, which is lower prevalence than a previous study revealed that (63.1%) of workers were not provided by PPE at work while (59%) were not receiving PPE training at work [13]**.**

In our study, older age group of workers (40 years or more) was associated with significantly high BLL, which is in agreement with **Hakim S** [11] who stated that workers with older age had significantly higher levels of blood lead. Furthermore, **Weyermann and Brenner,** [14] found by regression analysis that age was positively associated with BLL. Unlike **Nuwayhid *et al*.** [18] who stated that BLL of 15µg/dL or more was associated with younger age.

As regard residency, those living in rural areas had significantly high BLL that was unlike a previous study, which revealed that rural residents mean BLL was markedly lower than that of urban residents [15]. This high prevalence in rural residents of studied workers may be explained by prolonged exposure at their homes to lead based paints of old buildings in rural areas, which have not undergone renovation like buildings in new towns in urban areas **Hakim S** [11], also the higher percent of studied workers were from rural areas.

As regard smoking, there was not statistically significant difference, which is in consistence with **Potula and Hu,** [16] who stated that smoking was not significantly correlated with BLL. Unlike **Basit *et al*.** [8] and **Georeva *et al*.** [17], who reported that smoking significantly related to BLL, and BLL was higher among smokers than non-smokers.

Current occupation was significantly related to high BLL, and by regression analysis, it was a significant predictor of BLL. This is in agreement with **Potula and Hu,** [16] who revealed by regression analysis, that job category remained the strongest predictor of BLL ($p<0.05$).

As regard working duration, it was not significantly related to BLL, which is consistent with **Mostafa *et al*.** [12] and **Potula and Hu,** [16] who found no significant correlation between years of work and BLL. While **Nuwayhid *et al*.** [18] stated that years of work was associated with BLL, and **Hakim S** [11] reported that BLL increases with longer duration of work but not to a significant level.

As regard working hours per day, all workers worked the same number of hours per day with no significant difference. However, **Basit et al,** [8] found that BLL increases with increasing working hours per day, and also **Hakim S** [11] stated the same but their result was not significant. Regarding previous occupation, past exposure was significantly related to BLL, and by regression analysis it was a significant predictor for BLL. This is in agreement with **Morrow *et al*.** [19] who discovered by regression analysis that an interaction among bone lead and age seemed noteworthy for predicting rise in present BLL, suggesting that older individuals with past occupational lead exposure may face risk of recirculation of lead from bone to blood with advancing age. Our results showed that having access to air purification and ventilation systems at work is a major buffer against high BLL, which is corroborating the findings of **Lai et al.** [20], who discovered a strong association ($r = 0.62$) between ambient lead and BLL. Regression coefficient showed that better hygiene practices were more effective in reducing BLL than reducing ambient lead level**,** therefore while BLL was substantially connected with ambient lead level, it may not be efficiently lowered by reducing ambient lead level.

According to **Basit et al.** [8]**,** who also found that BLL increased among non-PPE users in compared to PPE users, employees who did not use PPE (mask and gown) were more likely to experience an increase in BLL. In addition, **Santosa et al.** [21] found that lead-exposed workers were substantially shielded from lead exposure when they wore masks. By regression analysis we found gown nonuse was a significant predictor for BLL, which is consistent with **La-Llave-León *et al*.** [22] who reported that not wearing a special work wear was significant predictor in predicting BLL in exposed workers.

## CONCLUSION

Cable industry is considered one of the dangerous industries that involving many hazards to which workers are exposed; of the most common risks is the high prevalence of elevated blood lead level. Therefore, attention must be directed to this important industry with many preventive measures and obligatory laws in order to protect workers from occupational lead poisoning, improve their health and guarantee their right to live a better and more productive life**.**

## RECOMMENDATIONS

**Applying Engineering measures** by using wet cleaning methods or a vacuum with a high-efficiency particulate air (HEPA) filter.

**Administrative measures as:**

Employers must make changes in the workplace or schedule that reduce or eliminate the worker exposure to lead like:

- Limit the amount of time a person spends at lead source by rotatory shifts and rotating workers.
- Provide special resting areas where workers can gain relief from hazardous lead sources.

**Concerned governmental authorities:**

- Must perform periodic checking and surveillance of workplace to ensure that noise and lead levels are maintained within permissible exposure limits.
- Obligatory laws for employers to provide required PPE for exposed workers with ensuring its continuous availability and training workers on correct using and cleaning it.
- Ensuring availability of properly designed PPE suitable for climatic working conditions and reduce discomfort of the workers.

**Medical measures:** by raising awareness by applying compulsory health education programs for exposed workers about lead health hazards and how to protect themselves by following the rules of safe work practice.

## Study limitations

This study has some limitations. First: This study has been conducted among cable workers at 10th of Ramadan City in Egypt, so results cannot be generalized over all cable industry workers in different workplaces. Second: The information bias can't be excluded as the data on sociodemographic, smoking, occupational characteristics and symptoms of auditory health problems were derived from the questionnaires.

- **Consent to Publish:** Not applicable**.**
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