Lead toxicity among working children and adolescents in Alexandria, Egypt

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التسمم بالرصاص بين الأطفال والمراهقين العاملين في الإسكندرية، مصر

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خلاصة: هناك عدد كبير من الأطفال والمراهقين الذين يعملون، ويتعرضون لمخاطر بيئية ومهنية مختلفة. ومن أجل تحديد مدى انتشار التسمم بالرصاص وما يتصل به من عوامل الاختطار، أجريت دراسة على 408 من الأطفال والمراهقين العاملين في الإسكندرية. ولقد تبين أن في 20.1% من أفراد العينة، كان مستوى الرصاص في الدم يساوي 25 ميكروغرام في الديسيلتر أو أكثر. وفيما يتعلق بالأطفال العاملين في ورش البطاريات في منطقتي الجمرك ومينا البصل، وجد أن فقر الدم والتدخين كانا مقترنين بدرجة ذات معنوية إحصائية باختطار مرتفع للتسمم بالرصاص. وبناء عليه، ينبغي إيلاء مزيد من الاهتمام إلى مشكلة التسمم بالرصاص بين العمال الأطفال، ولاسيما في المدن الحضرية الصناعية ذات الحركة المرورية الكثيفة وبيئة العمل التي تعوزها الحماية.

ABSTRACT A substantial number of children and adolescents work and are exposed to different occupational and environmental hazards. In order to identify the prevalence of lead toxicity and related risk factors, a study was conducted of 408 working children and adolescents in Alexandria. In 20.1% of those sampled, the blood lead level was ≥ 25 mg/dl. For children working in battery workshops in El-Gomrouk and Mina El-Bassal districts, anaemia and smoking were found to be significantly associated with a higher risk of lead toxicity. Thus, more attention should be paid to the problem of lead toxicity in working children, particularly in industrialized urban cities with heavy traffic and an unprotected work environment.

Le saturnisme chez les enfants et adolescents qui travaillent à Alexandrie (Egypte)

RESUME Un grand nombre d'enfants et d'adolescents travaillent et se trouvent exposés à divers risques professionnels et environnementaux. Afin de déterminer la prévalence du saturnisme et les facteurs de risque associés, une étude a été réalisée chez 408 enfants et adolescents qui travaillent à Alexandrie. Parmi ceux chez qui des prélèvements ont été effectués, 20,1% avaient un taux sanguin de plomb égal ou supérieur à 25 mg/dl. Pour les enfants travaillant dans des ateliers de réparation d'accumulateurs dans les quartiers d'El-Gomrouk et Mina El-Bassal, on a constaté que l'anémie et le tabagisme étaient associés de manière significative à un risque plus élevé de saturnisme. Il faut donc accorder plus d'attention au problème du saturnisme chez les enfants qui travaillent, en particulier dans les agglomérations urbaines industrialisées où la circulation est intense et le milieu de travail n'est pas protégé.

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Introduction

Lead toxicity, one of the most common syndromes of environmental origin, is a challenge to our health care. Yet it should be one of the easiest diseases to eradicate [*1,2*]. The problem becomes more serious among children as they tend to absorb higher amounts of lead than adults [*3*].

Elevated blood-lead (B-Pb) levels are known to cause a wide range of health problems in infants and children [*4–6*]. Lead toxicity causes haematological, gastrointestinal and neurological dysfunctions. Excess lead absorption early in life results in decreased cognitive function that persists into late adolescence [*7–9*]. Recent studies suggest that B-Pb levels that were previously considered safe may actually have deleterious effects on several neurobehavioural parameters [*10–12*]. Furthermore, results from longitudinal studies have shown that the negative effects of lead on cognitive functions persist across cultural and ethnic groups and socioeconomic classes [*13*].

In October 1991, the Centers for Disease Control and Prevention of the United States Department of Health and Human Services lowered the intervention level for B-Pb from 25 mg/dl to 10 mg/dl [*14*]. This lowering of the designated toxic blood level has significantly increased the number of children who are now considered to suffer from lead poisoning.

The incidence of clinical lead toxicity has been drastically reduced in industrialized countries, while there is a justifiable concern that the problem is of major importance in Egypt and other developing countries [*15*]. Factors which may elevate B-Pb levels include lead in paint, dust, soil and drinking water [*16–18*]. Lead from folk remedies, cosmetics, food supplements and utensils used for food preparation have caused epidemic and sporadic severe lead toxicity [*18*].

Alexandria Governorate is an industrial centre with a number of large factories on the outskirts of the city and several workshops dispersed in the urban areas. It suffers from intense traffic activity, with 271 million litres of petrol sold annually for vehicle use alone [*19*].

Child labour is mostly used in small workshops, which are more difficult to monitor than large factories. The percentage of children in the Egyptian labour force has been estimated to be 12% and economically active children represent 6.5% of the population for the age group 6–14 years [*20*]. The risk of lead toxicity in these children has not been evaluated before.

This study was conducted to estimate the frequency of lead toxicity among working children in Alexandria and to study the potential risk factors affecting lead toxicity in these children.

Subjects and methods

A cross-sectional study was carried out from September to December 1997 involving children and adolescents under 18 years of age working in different workshops in Alexandria, Egypt.

Alexandria Governorate is divided into 14 districts. In each, there is an industrialized area where most of the workshops are located. Three to five workshops were selected randomly from each of these areas. Children and adolescents (<18 years) working in the selected workshops were enrolled in the study. Abbis (representing a rural village), and Amria (representing a desert area) were also included in the study.

Informed consent to participate in the study was obtained from the child and the employer. A pre-tested questionnaire was used to collect data on demographic factors, socioeconomic status (including detailed housing conditions), personal and dietary habits, and employment details (e.g. age at starting work, type and duration of work). The presence of household facilities was indicated by the availability of water, a power supply and a family latrine or toilet; the absence of any of the three denotes a shortage in household facilities.

Kato–Katz thick-smear technique for stool analysis was used to diagnose intestinal helminths. Haemoglobin levels were measured by the cyanmet-haemoglobin method and packed cell volume using micro-scale capillary tubes. The children were considered anaemic if their haemoglobin (Hb) level was ≤ 12 g/dl. B-Pb levels were estimated by atomic absorption spectrophotometry using venous blood samples. B-Pb levels ≥ 25 µg/dl were considered to indicate lead toxicity. Anti-helminthic drugs and tonics were given free to those found to have intestinal helminths after laboratory investigations.

Statistical analysis

Data were analysed using *SPSS* (version 6). Bivariate association between the frequency of lead toxicity and different related factors was tested using the unadjusted odds ratios (OR) with 95% confidence intervals (95% CI). When more than two levels of a variable were considered, χ^2 for trend among the different levels was applied. Multiple regression analysis was used to examine the relationship between B-Pb level (dependent variable) and other quantitative explanatory variables. To identify significant predictors of lead toxicity while adjusting for all potential confounding effects of different covariables, a multiple logistic regression analysis with stepwise variable selection was applied.

The variable category with lowest frequency of lead toxicity was considered as a reference group(R). The following variables were entered into the logistic regression analysis: age in years (<12(R), 12–, ≥15); residence (Nadi El-Seid(R), El-Gomrouk, Mina El-Bassal, El-Labban, Abbis, Amria, Ezbet El-Matar, others); household facilities in house (absent(R), present); renovation of house with oil paint (no(R), yes); smoking (no(R), yes); drinking tea (no(R), yes); tea taken after a meal (never(R), sometimes, usually); Hb level (>12 g/dl(R), ≤12 g/dl); intestinal helminths (no(R), yes); occupation of the longest duration (carpentry(R), metal work, battery shops, others); total duration of work in months (<6(R), 6–12, >12); place of work (Nadi El-Seid(R), El-Gomrouk, Mina El-Bassal, El-Labban, Abbis, Amria, Ezbet El-Matar, others). The significant level for covariates entering and remaining in the logistic model was 10%. The association between exposures and outcome are expressed in terms of OR together with their 95% CI.

Results

The study was carried out on 408 working children and adolescents in Alexandria Governorate. Their ages ranged from 7 years to 18 years with a mean of 13.5 ± 2.3 years. Age at starting work was under 12 years in 46.1% of children; only 9.6% started working at or above the age of 15 years. Twenty-two per cent (22%) of the 408 children and adolescents studied were living in houses lacking one or more of the basic household facilities. Crowding index (number of persons per room) was 1–3 in 42.3% of cases, 4–6 in 44.8% and >7 in 12.9%.

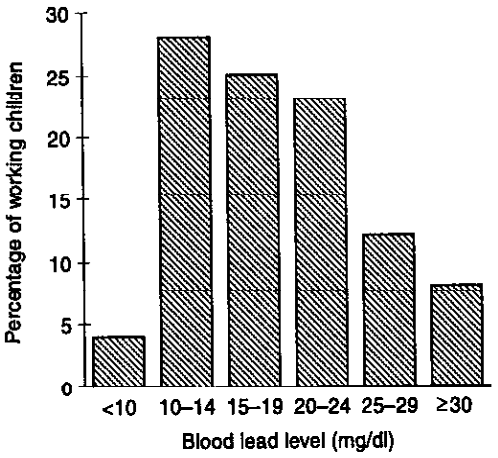

Figure 1 **Blood lead level in working children**

Figure 1 shows the distribution of B-Pb levels in the sample studied. B-Pb levels ranged from 8 µg/dl to 42 mg/dl (= 18.8 ± 6.9 mg/dl). In 96% of the children examined, the B-Pb level was ≥ 10 mg/dl and in 20% it was ≥ 25 mg/dl.

The relation between sociodemographic characteristics and lead toxicity is shown in Table 1. No significant increase in the risk of lead toxicity (B-Pb ≥ 25mg/dl) was related to age, availability of household facilities or recent renovation of the house with oil paint. Considering the district with lowest frequency of lead toxicity as a reference category, children living in El-Gomrouk (OR = 14.4, 95% CI 4.3–50.0) and Mina

Table 1 **Distribution of working children according to sociodemographic characteristics: cases presenting with lead toxicity (82) and those without (326)**

Variable	Lead toxicity[a]				Total	OR	95% CI
	Yes		No				
	No.	%	No.	%			
Age (years)							
< 12 [R]	14	17.5	66	82.5	80	1.0	
12–	37	20.7	142	79.3	179	1.2	0.6–2.6
15 and over	31	20.8	118	79.2	149	1.2	0.6–2.7
Residence (district)							
Nadi El-Seid [R]	8	8.9	82	91.1	90	1.0	
El-Gomrouk	14	58.3	10	41.7	24	14.4	4.3–50.0[b]
Mina El-Bassal	21	30.4	48	69.6	69	4.5	1.7–2.0[b]
El-Labban	4	16.0	21	84.0	25	1.9	0.4–8.2
Abbis	6	18.2	27	81.8	33	2.3	0.6–8.1
Amria	11	15.9	58	84.1	69	1.9	0.7–5.7
Ezbet El-Matar	6	15.6	32	84.2	38	1.9	0.5–6.7
Others	12	20.7	46	79.3	58	2.7	0.9–7.8
Household facilities							
Absent [R]	14	15.4	77	84.6	91	1.0	
Present	68	21.6	247	78.4	315	1.5	0.8–3.0
Renovation of house with oil paint							
No [R]	72	19.7	293	80.3	365	1.0	
Yes	10	24.4	31	75.6	41	1.3	0.6–3.0

[a] *Blood lead level ≥ 25 µg/dl* [b] *P < 0.05*
OR = Odds ratio *CI = confidence interval* [R] = *Reference category*

Table 2 **Personal habits and clinical characteristics of working children: cases presenting with lead toxicity (82) and those without (326)**

Variable	Lead toxicity*				Total	OR	95% CI
	Yes		No				
	No.	%	No.	%			
Smoking							
No[R]	73	19.2	308	80.8	381	1.0	
Yes	9	33.3	18	66.7	27	2.1	0.8–5.2
Drinking of tea							
No[R]	8	15.1	45	84.9	53	1.0	
Yes	74	20.8	281	79.2	355	1.5	0.6–3.6
Tea after meals							
Never[R]	12	16.7	60	83.3	72	1.0	
Sometimes	5	17.2	24	82.8	29	1.0	0.3–3.7
Usually	65	21.2	242	78.8	307	1.3	0.7–2.8
Hb level (g/dl)							
> 12[R]	50	19.3	209	80.7	259	1.0	
≤ 12	32	21.5	117	78.5	149	1.1	0.7–1.9
Intestinal helminths							
No[R]	30	17.2	144	82.8	174	1.0	
Yes	52	22.2	182	77.8	234	1.4	0.8–2.3
No. of parasites							
Free[R]	30	17.2	144	82.8	174	1.0	
Single	37	21.9	132	78.1	169	1.4	0.8–2.4
Multiple	15	23.1	50	76.9	65	1.3	0.8–2.3
(χ^2 for trend = 1.4. P = 0.23)							

*Blood lead level ≥ 25 µg/dl
OR = odds ratio CI = confidence interval [R]= Reference category Hb = haemoglobin

El-Bassal (OR = 4.5, 95% CI 1.7–12.0) were at the highest risk of lead toxicity.

Table 2 sets out the relation between personal habits and lead toxicity. Smoking and drinking tea show some increased risk of lead toxicity (yet statistically non-significant). Considering clinical characteristics, lead toxicity was somewhat more frequently encountered in children with Hb ≤ 12 g/dl (21.5% of subjects) than in those with Hb levels > 12 g/dl (19.3% of subjects). Also lead toxicity was more frequent in children suffering from intestinal helminths (22.2%) than helminth-free children (17.2%).

Occupation-related factors and their impact on the risk of lead toxicity are shown in Table 3. Lead toxicity was more frequently encountered in children working in battery shops (38.5%). Considering the total duration of work, lead toxicity was less frequent (14.3%) among children who had worked for less than 6 months as compared with those who had worked for longer periods (20.8% and 21.4%). The place of work was significantly associated with lead tox-

Table 3 **Distribution of working children according to occupation-related factors: cases presenting with lead toxicity (82) and those without (326)**

Variable	Lead toxicity[a]				Total	OR	95% CI
	Yes		No				
	No.	%	No.	%			
Occupation of the longest duration							
Carpenter[(R)]	1	7.1	13	92.9	14	1.0	
Battery shop worker	5	38.5	8	61.5	13	5.4	0.7–40.2
Others	16	23.5	52	76.5	68	3.3	0.5–22.9
Metal worker	18	23.1	60	76.9	78	3.2	0.5–22.3
Car services worker	42	17.9	193	82.1	235	2.5	0.4–16.9
Total duration of work (months)							
< 6[(R)]	10	14.3	60	85.7	70	1.0	
6–12	10	20.8	38	79.2	48	1.6	0.5–4.6
> 12	62	21.4	228	78.6	290	1.6	0.8–3.6
(χ^2 for trend = 1.56, $P = 0.21$)							
Place of work							
Nadi El-Seid[(R)]	7	7.5	86	92.5	93	1.0	
El-Gomrouk	17	54.8	14	45.2	31	14.9	4.7–49.1[b]
Mina El-Bassal	17	32.7	35	67.3	52	6.0	2.0–17.6[b]
El-Labban	16	27.6	42	72.4	58	4.7	1.6–13.7[b]
Abbis	6	18.2	27	81.8	33	2.7	0.7–10.1
Amria	10	14.9	57	85.1	67	2.2	0.7–6.7
Ezbet El-Matar	6	13.3	39	86.7	45	1.9	0.5–6.8
Others	3	10.3	26	89.7	29	1.4	0.3–6.7

[a] *Blood lead level ≥ 25 µg/dl* [b] *P < 0.05*
OR = odds ratio *CI = confidence interval* [(R)] *= Reference category*

icity and higher risks were seen in children working in El-Gomrouk (OR = 14.9, 95% CI 4.7–49.1), Mina El-Bassal (OR = 6.0, 95% CI 2.0–17.6) and El-Labban (OR = 4.7, 95% CI 1.6–13.7) (Table 3).

After adjusting for other potential confounders with regard to personal habits, only smoking was found to be a significant predictor of lead toxicity (Table 4). Allowing for other variables in the logistic model with regard to clinical characteristics, only a Hb level ≤ 12 g/dl was a significant predictor of lead toxicity. Adjusting for other potential confounders, children working in battery shops, and those working in El-Gomrouk and Mina El-Bassal were at a higher risk of lead toxicity.

Using the multiple regression model to study the relation between B-Pb level and other continuous variables, only the Hb level and the number of cigarettes smoked per day were significantly related to the lead level (Table 5).

Discussion

The findings of this study strongly illustrate the public health importance of lead toxicity among this group of children. The fre-

Table 4 **Predictors of lead toxicity (logistic regression analysis)**

Covariate	OR	95% CI
Occupation		
Carpenter[R]	1.0	
Battery shop worker	23.8	1.4–408.3[a]
Metal worker	3.3	0.7–39.2
Car services worker	2.1	0.2–24.3
Others	3.5	0.3–44.6
Place of work		
Ezbet El-Matar[R]	1.0	
El-Gomrouk	7.5	1.6–34.4[a]
Mina El-Bassal	5.0	1.1–23.8[a]
El-Labban	3.5	0.7–17.1
Abbis	2.7	0.2–39.5
Amria	1.7	0.4–8.5
Nadi El-Seid	0.9	0.2–4.2
Hb level (g/dl)		
> 12[R]	1.0	
≤ 12	2.1	1.1–4.0[a]
Smoking		
No[R]	1.0	
Yes	1.2	1.1–1.3[a]

Factors included in the model were: age, residence, household facilities, renovation of house with oil paint, type of work, place of work, total duration of work, smoking, drinking tea, anaemia and intestinal helminths.

[a] *P < 0.05*

Hb = haemoglobin

Table 5 Predictors of blood lead levels (multiple regression analysis)

Variable	β	t
Haemoglobin	–0.18	2.44[a]
Haematocrit value	–0.01	0.17
Ferritin	0.003	0.05
Total ferrous intake	0.05	0.75
Duration of work (months)	–0.02	0.24
No. of cigarettes per day	0.16	2.39[a]
No. of cups of tea per day	0.04	0.58

[a] *P < 0.05*

quency of lead toxicity among working children and adolescents in Alexandria Governorate is alarmingly high (96.1% ≥ 10 mg/dl and 20.1% ≥ 25 mg/dl). The need for action becomes even more urgent if we consider the recommendations of the Centers for Disease Control in October 1991 to lower the intervention level for B-Pb from 25 mg/dl to 10 mg/dl [*14*]. Since exposure to lead is a threat to child health in most industrialized societies, special attention should be given to lead levels in children even marginally higher than those considered safe [*21*].

Working children are exposed to multiple sources of lead. Besides the particular hazards of exposure related to the work environment, they are more exposed to street traffic and they consume more street food which has been found to contain higher lead contamination.

The place of work proved to be a significant predictor of lead toxicity. This was to be expected as most of these children spend the majority of their day at work. The higher frequency of lead toxicity among children and adolescents working in El-Gomrouk and Mina El-Bassal should be a subject of detailed study to reveal the possible underlying causes. The heavy traffic noted in these districts could be one of the important causes as virtually all of the petrol used in Alexandria at the time of conducting this study contained lead additives. Approximately 20% of cars use 90-octane petrol with 0.9 g/l of lead, while 80% use 80-octane petrol with 0.4 g/l of lead. In a previous study in some regions covered in the present study, high levels of lead in the air were found in El-Gomrouk and Mina El-Bassal (0.56 mg/m^3 and 0.61 mg/m^3 respectively) while a lower lead level was reported in Ezbet El-Matar (0.21 mg/m^3) [*22*]. This coincides with the proportion of

lead toxicity in the different areas reported in our study.

The relation between malnutrition, parasitic infection and lead toxicity is of interest, particularly in developing countries. Although parasitic infection was associated with a higher (but statistically non-significant) risk of lead toxicity as shown in bivariate analysis in Table 2, only the Hb level ≤ 12g/dl was found to be an independent predictor of lead toxicity after adjusting for other covariates (Table 4). This was confirmed by the significant inverse linear relation found between Hb level and B-Pb level in the multiple regression model (Table 5). This is supported by Schwartz et al. who found a dose–response relationship between B-Pb levels and haematocrit values in young children [*23*]. Factors impeding ferrous absorption could enhance lead absorption [*24*], and the lack of iron may both exacerbate the effects of excess lead and independently may adversely affect intellectual function [*25*].

Regarding the relation between smoking and lead toxicity, and in accordance with our results, Grandjean found that increased blood lead concentrations were related to smoking and drinking alcohol [*26*]. It is difficult to interpret the association between smoking and increased lead levels, but it may be attributed to the ingestion of lead (contamination from hands during work) or increased absorption of inhaled lead in smokers.

Battery workshops and other work places where there is a high risk of lead toxicity should be under strict supervision to prohibit (or limit) the involvement of children in such work.

In conclusion, more attention to the problem of lead toxicity in working children and adolescents living in developing countries is warranted, particularly in industrialized urban cities with heavy traffic and unprotected work environments.

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Protection and promotion of occupational health

Available statistical data on occupational health and work safety in countries of the Eastern Mediterranean Region, with particular reference to morbidity and mortality from disease and accidents attributed to working conditions, remain scanty and grossly underestimate the magnitude of the problem. Information on specialized health personnel rendering services to workers in manufacturing, agriculture, construction, mines and small-scale factories is also incomplete. Efforts are being exerted by many Member States in collaboration with WHO to fill this gap.

During 1997, as part of national efforts to develop and strengthen national programmes on occupational health and work safety, the Regional Office collaborated with some countries in the conduct of national situation analyses to obtain reliable information on mortality and morbidity patterns of workers of different categories and at organized and unorganized work sites in order to formulate appropriate national strategies which would respond to the local needs.

In order to assist countries of the Region in their efforts to introduce occupational health services into their national primary health care systems, the Regional Office held an intercountry consultation for development of a training course for community health workers in occupational health in 1997. The consultation outlined a training framework that would enable community health workers to recognize most common hazards in the workplace, create the know-how for controlling them and use the support available to them for referral and medical consultation. As a result, a model training manual is now being prepared in the Regional Office and is expected to be available to countries of the Region in 1998.

Source: The Work of WHO in the Eastern Mediterranean Region. Annual Report of the Regional Director 1 January–31 December 1997, *page 73*.