

Blood Lead Levels in 1-3 Year Old Lebanese Children: A Cross-sectional study

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Abstract

Background

Childhood lead poisoning has not made the list of national public health priorities in Lebanon. This study aims at identifying the prevalence and risk factors for elevated blood lead levels (BLL \geq 10 ug/dl) among 1-3 year old children. It also examines the need for universal blood lead screening.

Methods

This is a cross-sectional study of 281 well children, presenting to the pediatric ambulatory services at the American University of Beirut Medical Center in 1997-98. Blood was drawn on participating children for lead analysis and a structured questionnaire was introduced to mothers asking about social, demographic, and residence characteristics, as well as potential risk factors for lead exposure. Children with BLL \geq 10 ug/dl were compared to those with BLL $<$ 10 ug/dl.

Results

Mean BLL was 6.6 ug/dl (median 6.0; range 1-16; standard deviation 2.6) with 39 (14%) children with BLL \geq 10 ug/dl. Logistic regression analysis showed that elevated BLL was associated with paternal manual jobs (odds ratio [OR]: 4.74), residence being located in high traffic areas (OR: 4.59), summer season (OR: 4.39), using hot tap water for cooking (OR: 3.96), exposure to kohl (OR: 2.40), and living in older buildings (OR: 2.01).

Conclusion

Lead screening should be offered to high-risk children. With the recent ban of leaded gasoline in Lebanon, emphasis should shift to other sources of exposure in children.

Background

Lead toxicity remains to be a shared concern for many countries, both developed and developing. Despite differences in the sources of exposure, children continue to present a uniquely vulnerable group, especially during the first three years of life.[1,2] In addition to the inhalation route, children may ingest lead through contaminated dust, soil, and drinking water.[3] Moreover, they absorb lead at a higher rate than adults and their nervous system is more susceptible to its detrimental toxic effects [2,3], thus resulting in neurocognitive delay at blood lead levels (BLL) as low as 10 µg/dl [0.48 µmol/L].[4,5]

An earlier study on working men at low occupational hazard for lead toxicity in Beirut revealed that BLL was strongly associated with smoking and commuting.[6] Commuting came at no surprise in a country where close to 90% of the fleet of one million vehicles was operating on leaded gasoline [7], until early 2002 when leaded gasoline was banned.

In addition to ambient air lead and passive smoking, children in Lebanon may be exposed to lead through other sources, such as tap water delivered by lead-soldered pipes, paint, and kohl (traditional eyeliner rich in lead). Despite these red flags, childhood lead poisoning has not made the list of national public health priorities. Pediatricians have rarely reported cases of lead poisoning in Lebanese children. This may be attributed to failure to suspect the toxicity, probably reflecting BLL in the sub-clinical range (< 20 µg/dl).

The blood lead level above which public health action should be taken has been reduced by the US Centers for Disease Control and Prevention (CDC) to 10 µg/dl, based on the accumulating evidence of lead toxicity at low levels.[3] This warrants an active approach to understand the magnitude and determinants of lead

poisoning among children in Lebanon. The proposed study aims at measuring the prevalence of lead poisoning, defined as $BLL \geq 10$ ug/dl, among children 1-3 years of age, and at identifying the risk factors for elevated blood lead levels in this population. It also examines the need for universal blood lead screening.

Methods

This is a cross-sectional study on 1-3 year old children presenting for routine check-up at the private, and outpatient pediatric ambulatory services of the American University of Beirut Medical Center (AUBMC), in Beirut-Lebanon. Children this age were targeted because it is the age of greatest hand-to-mouth and crawling exploratory activity, and a period of fast brain growth where exposure to lead is documented to cause irreversible damage.[4] AUBMC pediatric private clinics charge regular visit fees, while the outpatient department charges nominal fees. Although AUBMC is a tertiary medical center, patients from all over Lebanon use its ambulatory services as well for primary health care. The majority of patients though come from the city of Beirut and its suburbs, which host more than 30% of the Lebanese population.

In the outpatient department, children were identified from the roster of next day appointments. Those presenting for regular checkup or vaccination were potential candidates for the study. As for the private clinics, three busy pediatricians provided the names of children eligible for the study.

Subjects

Between August 1997 and July 1998, a total of 500 children were identified. Mothers were approached in the waiting area and informed about the

study. Of these, 291 accepted to be interviewed, and signed an informed consent. Only 289 mothers allowed blood withdrawal on their children. Non-participants included refusals, no-shows, and non-eligible children. Excluded were sick or febrile children and those with a diagnosis of a chronic disease or hematological disorder. The final sample thus included 281 children. No information was collected about the 219 non-participating mothers or their children.

Data collection

A trained interviewer, using a standardized questionnaire with mostly closed-ended questions, interviewed all mothers. The interviewer inquired about the socio-demographic characteristics of the family; the medical and nutritional history, and health status of the child; and potential environmental and household sources of exposure to lead (e.g., closeness of residence to industry and construction sites; traffic; parent's occupations; use of kohl, hot tap water, or glazed pottery).

A trained phlebotomist in the hospital drew 2-3 milliliters of venous blood from each child, into metal-free heparin tubes, which were stored at 4° C for later analysis. Batches of 50-100 tubes were express-mailed, in a box of ice, to New York for analysis at an accredited clinical laboratory at the Columbia University College of Physicians and Surgeons. Blood lead level was measured following a standardized analytical method using Inductively Couple Plasma mass spectrometry (ICPMS) or Atomic Absorption Spectrophotometry-Graphite furnace (AAS-GF). Blood was also collected in another tube for the analysis of hematocrit, iron, and iron binding capacity.

The Research Committee and the Institutional Review Board, at the American University of Beirut, approved the study protocol. A pamphlet on potential sources of lead and advisable activities that may reduce children's exposure was

specifically prepared for this study, and was distributed at the end of the interview to all contacted mothers regardless of participation.

Data analysis

The CDC permissible childhood BLL of 10 ug/dl was used as a cutoff point. The socio-demographic characteristics, residence characteristics, and potential risk factors for exposure to lead among children with a BLL ≥ 10 ug/dl were compared to those of children with a BLL < 10 ug/dl. Due to the small number of children with BLL ≥ 10 ug/dl and whenever possible, categorical variables were collapsed into a smaller number of categories to avoid cells with less than 5 individuals. The potential of exposure to lead in the parent's occupation or hobbies was assigned with no knowledge of the child's BLL. Chi-square analysis and Student's t-test were used to test statistical significance for categorical and continuous variables, respectively. The non-parametric test of Mann-Whitney U was used for continuous variables, which lacked normal distribution. Statistical significance was set at a P value of 0.05. Backward logistic regression analysis was performed to identify the best model that explains a BLL of 10 ug/dl or above. Age, gender, type of clinic and all variables with a $P < 0.20$ in the bivariate analysis (Tables 1 to 3) were tested in the model. Interaction terms were tested but none was found to be of statistical significance. SPSS for Windows, version 11, was used for statistical analysis.

Results

Of 281 children, 133 (47.3%) were girls. The mean age was 23.1 months (SD: 8.6), with a range of 11 to 44 months. The ratio of outpatient department to private clinics subjects was 2 to 1. Figure 1 shows the distribution of BLL. The mean BLL

was 6.6 ug/dl (SD: 2.6), with a range of 1 to 16 µg/dl and a median of 6.0 ug/dl. There were 39 (14%) children with BLL \geq 10µg/dl (Table 1). Children with BLL \geq 10 ug/dl came from less educated and lower income families, as compared to those with BLL $<$ 10 ug/dl ($P < 0.01$), and a higher proportion of their fathers and mothers worked in manual jobs ($P < 0.01$) (Table 1). There was no statistically significant difference in BLL by sex, with a mean of 6.8 ug/dl (SD 2.7) among males and 6.4 ug/dl (SD 2.6) among females ($P = 0.29$).

Almost all the residents of Beirut and its suburbs live in apartment buildings. Table 2, which compares the overall indoor and outdoor environmental conditions of children's residences, revealed that a significantly higher proportion of children with BLL \geq 10 ug/dl lived in buildings that were located near traffic-jammed roads ($P < 0.03$), as compared to those with BLL $<$ 10 ug/dl. A seasonal effect was also observed with most of the children with BLL \geq 10 ug/dl identified in the summer and fall seasons ($P < 0.02$).

Table 3 compares the distribution of potential risk factors for lead exposure between the two groups of children: those with BLL \geq 10 ug/dl and those with BLL $<$ 10 ug/dl. A BLL \geq 10 ug/dl was significantly associated with the use of hot tap water for cooking or preparation of milk ($P < 0.03$). The application of Kohl to the eyes of children was significantly associated with elevated BLL ($P < 0.001$). Kohl was applied either to the eyes (92.7%), umbilical cord (2.4%), or both (4.9%), mostly in the first 3 months of age (92.5%). In addition, paternal occupations with a potential for moderate to high exposure to lead had a statistically significant association with elevated BLL in children ($P < 0.01$).

A comparison of health status, nutrition, and the status of iron deficiency between the two groups of children revealed that a higher proportion of children with lower BLL were reported to have lack of appetite (40% v 21%; $P <$

0.02) and fatigue (9% v 0%; $P < 0.05$), as compared to children with high BLL (selected variables shown in table 3).

Table 4 presents the findings of the multivariate logistic regression analysis. Elevated BLL ($\geq 10 \mu\text{g}/\text{dl}$) was associated with paternal manual jobs (odds ratio [OR]: 4.74), residence being located in high traffic areas (OR: 4.59), summer season (OR: 4.39), using hot tap water for cooking (OR: 3.96), exposure to kohl (OR: 2.40), and living in older buildings (OR: 2.01).

We reviewed the characteristics of the children with the highest BLL, two children with a BLL of 15 $\mu\text{g}/\text{dl}$ (a 15-month-old girl and a 37-month-old boy) and a 29-month-old boy with a BLL of 16 $\mu\text{g}/\text{dl}$. The only risk factors consistently identified for the three children were living in older buildings (> 20 years of age), and having moderately to very dusty homes

Discussion

A prevalence of 14% of blood lead levels $\geq 10 \mu\text{g}/\text{dl}$, among 1-3 year old well children presenting for routine pediatric visits in Beirut, is much higher than the prevalence of BLL $\geq 10 \mu\text{g}/\text{dl}$ reported among children in economically advantaged countries.[8-10] In these countries, decrease in blood lead levels was mainly attributed to the elimination of leaded petrol and lead-soldered food cans. In spite of this, the prevalence of lead poisoning is still high among urban low-income populations, due to other sources of exposure.[8,9] This is also true, although not consistent, in the less advantaged countries, where children are still exposed to lead from leaded gasoline, traditional cosmetics, lead water pipes, and lead-soldered food cans. The reported BLL in these countries ranged from a level as low as a mean of

1.96 µg/dl in Jordan,[11] to as high as 50-87% of children having BLL \geq 10 µg/dl in Cape Peninsula, South Africa,[12] and Dhaka, Bangladesh.[13]

Risk factors

In this study, living in a traffic-jammed area more than quadrupled the children's risk for an elevated BLL. This finding is consistent with previous reports,[13-15] and is attributed to the fact that, at the time of the study, 85-90% of a relatively old fleet of vehicles in Lebanon was operating on leaded gasoline, in the absence of any emission control program.[7] Young children, who spent most of their time at home, may have been exposed to lead through direct inhalation, or by ingesting deposited lead dust. However, perceived dustiness of the home and low frequency of dusting were not found to be associated with elevated BLL. This is consistent with the findings of Haynes et al. [16] who reported no significant effect of dust control on the proportion of children with BLL \geq 10µg/dl. Dust control was only effective in reducing the proportion of children with BLL \geq 15µg/dl or BLL \geq 20µg/dl.

Another risk factor found to be strongly associated with elevated BLL is the manual job of the father, which presents an important health warning in a country with a low priority for work-related health and safety issues.[17] This association has been previously reported and linked to the exposure of children to the contaminated clothes at home.[18,19] Our study questionnaire, however, did not probe into how work clothes were handled or washed at home.

There was a clear seasonal effect on BLL, with the highest proportion of children with elevated BLL detected in summer and fall. This association could be explained by the relatively warmer periods and higher outdoor activities in these

seasons, as suggested by Yiin et al. [20] although their study was substantiated by indoor and outdoor environmental samples.

The association between use of hot tap water for cooking or milk preparation and elevated BLL strongly suggests possible exposure to lead from lead pipes or lead-soldered pipes. A national study on all groundwater sources used in Lebanon reported non-detectable lead content, or lead levels that were within international standards.[21] Lead content, however, has not been assessed in the household, or within the old distribution network, which has been maintained or replaced only recently.

Other risk factors associated with higher BLL, but with less strength, were identified. These could have been overshadowed by the effect of lead in gasoline, or by the exposure to contaminated clothes. The use of kohl on the eyes or umbilical cords of children is one such factor. In Lebanon, this practice is much lower than what is reported from other countries, such as the Gulf Arab countries or India.[22,23] However, the 15% prevalence in our study is high and is another health flag that needs to be addressed. As for living in older buildings, also found to be associated with an increased risk for elevated BLL after adjusting for other risk factors, this finding may be due to the leaded paint used in these buildings, or due to chance.

A few risk factors for elevated BLL deserve mentioning although they did not make it into the regression model. These include the presence of small industries in residential buildings, which is very common in Beirut and its suburbs. Proximity to industrial activity is a known risk factor,[18] mostly explained by exposure to lead particles in the air or dust. They also include father's and mother's low education, low income (< \$ 500 a month), and being an outpatient department

client. These are socioeconomic indicators whose effects might have been mediated through other variables, such as father's occupation.

Other potential risk factors for elevated BLL among children, such as male gender, the use of glazed pottery, passive smoking, or eating canned food,[2, 3] were not found to be significant in this study. No differences were noted in the mean BLL or proportion of elevated BLL between boys and girls. An elevated BLL among boys is usually attributed to more exploratory activities, which was not assessed in this study. Only 7% of the mothers reported using glazed pottery to cook or serve food, and it was more common among the families of children with BLL within the permissible limits. This suggests that better-quality glazed pottery were being used,[24] or that children were not eating from food served in pottery. As for passive smoking, the fact that 68% of the children were exposed may have reduced the power of detecting a significant difference. The lack of association between serving canned food and elevated BLL may reflect the success of an ongoing policy to ban lead soldered food cans in Lebanon.

Methodological issues

There are certain limitations to this study that merit discussion. This study is cross-sectional in design. Habits and exposures may differ by season and age, especially among young children, thus affecting the blood lead level. The study sample, which is based in a medical center that also serves as a primary care provider, may not be representative of the population as a whole. Accounting for failure to show for the appointment and ineligibility, we estimated the participation rate to be approximately 70%, however no information was collected on the children whose mothers refused to participate. The study sample size did not provide enough statistical power to compare the distribution of different variables between the two

groups of children. In addition, exposures and health outcomes were self-reported. The standardized questionnaire, which was introduced by a well-trained interviewer, might have reduced the bias but did not resolve the innate limitations of recall information. This was most striking with the questions about health outcomes, where contrary to our expectations, children with higher BLL were reported to have less health complaints (fatigue, lack of appetite). Such a finding could be attributed to a perception issue, as mothers of children with lower BLL were more educated, and perhaps, had higher expectations or stricter standards regarding the health and nutrition of their children.

Conclusions

The main question to be addressed here is whether there is a need for universal lead screening of children in Lebanon. The cost of universal screening, and of children's anxiety, which are cited by opponents [25], is outweighed by the short and long-term savings of medical care, special education, and losses in productivity reported by proponents.[26-28] Caution should be exerted in using a cross-sectional clinic-based study to make a recommendation. However, the detection of no children in this study with a BLL above 16 ug/dl and only 1% with a BLL of 15-16 ug/dl, and the lack of reported cases of severe childhood poisoning favor targeted screening, addressed at high risk children. The limited resources within the country and the recent decision to ban leaded gasoline further support this recommendation. Pediatricians could provide general hygienic recommendations and screen high-risk children for lead. Children whose fathers work in occupations with potential exposure to lead, and whose families use kohl, glazed pottery for food preparation, or hot tap water for milk preparation, may be at a higher risk for lead exposure. The use of low

cost kits to test for lead in the home environment could supplement the pediatrician's effort to manage elevated BLL, especially in the absence of a national lead prevention program. Future research should document the expected drop in BLL among children at a national level and examine the contribution of sources, such as tap water, paint and kohl, to elevated BLL.

List of abbreviations

BLL, blood lead level; AUBMC, American University of Beirut Medical Center; OR, odds ratio; CI, confidence interval.

Competing interests

None.

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Authors' contributions

IN designed the study, supervised data collection, performed the statistical analysis, and drafted the manuscript. MN participated in data collection, statistical analysis, and drafting of manuscript. SM participated in study design, data collection and analysis. SK participated in design of questionnaire, data collection and analysis. GS participated in the conception of the study and study design. MM participated in the study conception and design. MA participated in study design, data analysis, and drafting of manuscript. All authors read and approved the final manuscript.

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References

1. Mendelsohn AL, Dreyer BP, Fierman AH, Rosen CM, Legano LA, Kruger HA, Lim SW, Courtlandt CD: **Low-level lead exposure and behavior in early childhood.** *Pediatrics* 1998, **101**: E10.
2. International Programme for Chemical Safety: **Inorganic Lead. EH Criteria 165.** Geneva, World Health Organization 1995.
3. Centers for Disease Control: **Preventing lead poisoning in young children: A statement by the Centers for Disease Control.** Atlanta, Centers for Disease Control 1991.
4. Bellinger DC, Stiles KM, Needleman HL: **Low-level lead exposure, intelligence and academic achievement: a long-term follow-up study.** *Pediatrics* 1992, **90**: 855-861.
5. Wasserman GA, Liu X, Popovac D, Factor-Litvak P, Kline J, Waternaux C, LoIacono N, Graziano JH: **The Yugoslavia Prospective Lead Study: contributions of prenatal and postnatal lead exposure to early intelligence.** *Neurotoxicol Teratol* 2000, **22**: 811-818.
6. Nuwayhid I, McPhaul K, Bu-Khuzam R, Duh SH, Christenson RH, Keogh JP: **Determinants of elevated blood lead levels among working men in Greater Beirut.** *Leb Med J* 2001, **49**: 132-139.
7. Chaaban FB, Nuwayhid I, Djoundourian S: **A study of social and economic implications of mobile sources on air quality in Lebanon.** *Transportation Research-Part D* 2001, **6**: 347-355.

8. Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC: **Exposure of the U.S. population to lead, 1991-1994.** *Environ Health Perspect* 1998, **106**: 745-750.
9. Karr M, Mira M, Causer J, Burn M: **Blood lead concentrations and iron status of preschool children from low income families.** *Med J Aust* 1997, **166**: 53.
10. Stromberg U, Schutz A, Skerfving S: **Substantial decrease of blood lead in Swedish children, 1978-94, associated with petrol lead.** *Occup Environ Med* 1995, **52**: 764-769.
11. Dabbas MA, Al-Zoubi MA: **Blood lead level in the Jordanian population.** *Saudi Med J* 2000, **21**: 964-967.
12. von Schirnding Y, Mathee A, Robertson P, Strauss N, Kibel M: **Distribution of blood lead levels in schoolchildren in selected Cape Peninsula suburbs subsequent to reductions in petrol lead.** *S Afr Med J* 2001, **91**: 870-872.
13. Kaiser R, Henderson AK, Daley WR, Naughton M, Khan MH, Rahman M, Kieszak S, Rubin CH: **Blood lead levels of primary school children in Dhaka, Bangladesh.** *Environ Health Perspect* 2001, **109**: 563-566.
14. Pirkle JL, Brody DJ, Gunter EW, Kramer RA, Paschal DC, Flegal KM, Matte TD: **The decline in blood lead levels in the United States. The National Health and Nutrition Examination Surveys (NHANES).** *JAMA* 1994, **272**: 284-291.
15. Hashim JH, Hashim Z, Omar A, Shamsudin SB: **Blood lead levels of urban and rural Malaysian primary school children.** *Asia Pac J Public Health* 2000, **12**: 65-70.

16. Haynes E, Lanphear BP, Tohn E, Farr N, Rhoads GG: **The effect of interior lead hazard controls on children's blood lead concentrations: a systematic evaluation.** *Environ Health Perspect* 2002, **110**:103-107.
17. Nuwayhid I: **Occupational Health in Lebanon: Overview and Challenges.** *Int J Occup Environ Health* 1995, **1**: 349-358.
18. Morales Bonilla C, Mauss EA: **A community-initiated study of blood lead levels of Nicaraguan children living near a battery factory.** *Am J Public Health* 1998, **88**: 1843-1845.
19. Whelan EA, Piacitelli GM, Gerwel B, Schnorr TM, Mueller CA, Gittleman J, Matte TD: **Elevated blood lead levels in children of construction workers.** *Am J Public Health* 1997, **87**: 1352-1355.
20. Yiin LM, Rhoads GG, Liroy PJ: **Seasonal influences on childhood lead exposure.** *Environ Health Perspect* 2000, **108**:177-182.
21. Jurdi M (editor): **Survey on the Quality of Potable Water in Lebanon.** *Beirut, Ministry of Hydraulic and Electrical Resources and UNICEF* 1998.
22. Alkhawajah AM: **Alkohol use in Saudi Arabia. Extent of use and possible lead toxicity.** *Trop Geogr Med* 1992, **44**: 373-377.
23. Smar A, Madan N: **Public health. Surma: a cause for concern.** *Health Visit* 1990, **63**: 379-380.
24. Acra A, Dajani R, Raffoul Z, Karahagopian Y: **Lead-glazed pottery: a potential health hazard in the Middle East.** *Lancet* 1981, **1**: 433-434.
25. Schoen EJ: **Lead toxicity in the 21st century: will we still be treating it?** [letter] *Pediatrics* 1992, **90**: 481-482.
26. Chisolm, JJ Jr.: **The road to primary prevention of lead toxicity in children.** *Pediatrics* 2001, **107**: 581-583.

27. Landrigan PJ: **Pediatric lead poisoning: is there a threshold?** *Public Health Rep* 2000, **115**: 530-531.
28. Needleman HL: **Childhood lead poisoning: the promise and abandonment of primary prevention.** *Am J Public Health* 1998, **88**: 1871-1877.

Figure 1. Distribution of blood lead level among 1-3 year old children

Table 1. Socio-demographic characteristics of children by blood lead level

	Blood lead level (ug/dl)			P-value
	<i><10 (N=242)</i>	<i>>=10 (N=39)</i>	<i>Total (N=281)</i>	
	n (%)	n (%)	n (%)	
Blood lead level (ug/dl)				
< 5	59 (24.4)	--	59 (21.0)	
5 – 9	183 (75.6)	--	183 (65.1)	
10 – 14	--	36 (92.3)	36 (12.8)	
15 – 19	--	3 (7.7)	3 (1.1)	
Mean BLL (Range)	5.83 (1 – 9)	11.38 (10 – 16)	6.60 (1 – 16)	
Age (months)				
11 - 23	125 (51.7)	17 (43.6)	142 (50.5)	0.35
24 – 44	117 (48.3)	22 (56.4)	139 (49.5)	
Mean age (SD)	22.9 (8.6)	24.8 (8.7)	23.1 (8.6)	0.19
Gender				
Males	127 (52.5)	21 (53.8)	148 (52.7)	0.87
Type of clinic				
Outpatient	170 (70.8)	33 (84.6)	203 (72.8)	0.07
Private	70 (29.2)	6 (15.4)	76 (27.2)	
Mother's Education				
Up to middle school	107 (44.4)	27 (69.2)	134 (47.9)	0.004
Secondary and above	134 (55.6)	12 (30.8)	146 (52.1)	
Father's Education				
Up to middle school	109 (45.6)	29 (74.4)	138 (49.6)	0.001
Secondary and above	130 (54.4)	10 (25.6)	140 (50.4)	
Mother's work				
Housewife	200 (82.6)	34 (87.2)	234 (83.3)	0.009
Non-manual	39 (16.1)	2 (5.1)	41 (14.6)	
Manual	3 (1.2)	3 (7.7)	6 (2.1)	
Father's work				
Non-manual*	137 (56.8)	9 (23.1)	146 (52.1)	0.001
Manual	104 (43.2)	30 (76.9)	134 (47.9)	

Number of siblings				
0	81 (33.5)	12 (30.8)	93 (33.1)	0.84
1-2	118 (48.8)	21 (53.8)	139 (49.5)	
>= 3	43 (17.8)	6 (15.4)	49 (17.4)	
Family monthly income (US \$)				
< 200	11 (4.5)	5 (12.8)	16 (5.7)	0.004
200 - 499	99 (40.9)	17 (43.6)	116 (41.3)	
500 – 999	71 (29.3)	16 (41.0)	87 (31.0)	
>= 1000	61 (25.2)	1 (2.6)	62 (22.1)	

Note: Missing data in some variables.

* Non-manual includes 4 who are not working.

Table 2. Residence characteristics of children by blood lead level

	Blood lead level (ug/dl)			P-value
	<i><10 (N=242)</i>	<i>≥10 (N=39)</i>	<i>Total (N=281)</i>	
	n (%)	n (%)	n (%)	
Area of residence				
Beirut	114 (47.1)	24 (63.2)	138 (49.3)	0.13
Suburbs of Beirut	84 (34.7)	11 (28.9)	95 (33.9)	
Outside Beirut	44 (18.2)	3 (7.9)	47 (16.8)	
Season				
Winter (01-03)	59 (24.4)	6 (15.4)	65 (23.1)	0.02
Spring (04-06)	59 (24.4)	3 (7.7)	62 (22.1)	
Summer (07-09)	42 (17.4)	9 (23.1)	51 (18.1)	
Fall (10-12)	82 (33.9)	21 (53.8)	103 (36.7)	
Age of building (years)				
≤ 20	137 (60.6)	16 (44.4)	153 (58.4)	0.07
> 20	89 (39.4)	20 (55.6)	109 (41.6)	
Home last painted (years)				
≤ 3	160 (67.2)	21 (55.3)	181 (65.6)	0.15
> 3	78 (32.8)	17 (44.7)	95 (34.4)	
Dustiness of home				
Very dusty	85 (35.6)	15 (38.5)	100 (36.0)	0.63
Moderately dusty	53 (22.2)	6 (15.4)	59 (21.2)	
Not/ a little dusty	101 (42.3)	18 (46.2)	119 (42.8)	
Frequency of dusting				
Daily	173 (73.3)	24 (61.5)	197 (71.6)	0.13
Not daily	63 (26.7)	15 (38.5)	78 (28.4)	
Location of building				
Main road	92 (38.5)	17 (43.6)	109 (39.2)	0.55
Side road	147 (61.5)	22 (56.4)	169 (60.8)	
Industry in same building*				
Yes	30 (12.9)	9 (23.1)	39 (14.3)	0.09
No	203 (87.1)	30 (76.9)	233 (85.7)	
Traffic jam in area				
Always/often	134 (56.1)	29 (74.4)	163 (58.6)	0.03
Rarely	105 (43.9)	10 (25.6)	115 (41.4)	

Nearby construction works

Yes	140 (58.6)	23 (59.0)	163 (58.6)	0.96
No	99 (41.4)	16 (41.0)	115 (41.4)	

Note: Missing data in some variables.

* Small industries, such as mechanics, furniture, or paint shop.

Table 3. Other potential risk factors for children's exposure to lead by blood lead levels

	Blood lead level (ug/dl)			P-value
	<i><10 (N=242)</i>	<i>≥10 (N=39)</i>	<i>Total (N=281)</i>	
	n (%)	n (%)	n (%)	
Overall health status				
Good-Excellent	188 (77.7)	30 (76.9)	218 (77.6)	0.92
Poor-Satisfactory	54 (22.3)	9 (23.1)	63 (22.4)	
Iron deficiency				
No	163 (76.9)	26 (66.7)	189 (67.7)	0.94
Yes, without anemia	27 (11.3)	4 (10.3)	31 (11.1)	
Yes, with anemia	50 (20.8)	9 (23.1)	59 (21.1)	
Source of drinking water				
Municipality	88 (36.4)	20 (51.3)	108 (38.4)	0.08
Other†	154 (63.6)	19 (48.7)	173 (61.6)	
Source of water for cooking				
Municipality	144 (60.3)	25 (64.1)	169 (60.8)	0.65
Other†	95 (39.7)	14 (35.9)	109 (39.2)	
Use hot tap water for milk or cooking				
Yes	14 (5.9)	6 (15.8)	20 (7.2)	0.03
No	225 (94.1)	32 (84.2)	257 (92.8)	
Runs tap water before use				
Yes	121 (51.3)	23 (59.0)	144 (52.4)	0.37
No	115 (48.7)	16 (41.0)	131 (47.6)	
Child eats canned food				
Yes	73 (30.2)	12 (30.8)	85 (30.2)	0.94
No	169 (69.8)	27 (69.2)	196 (69.8)	
Use glazed pottery for food‡				
Yes	19 (8.2)	1 (2.6)	20 (7.4)	0.33
No	213 (91.8)	38 (97.4)	251 (92.6)	
Pica behavior§				
Yes	66 (27.7)	9 (23.1)	75 (27.1)	0.54
No	172 (72.3)	30 (76.9)	202 (72.9)	
Ever applied kohl on child				
Yes	30 (12.4)	13 (33.3)	43 (15.3)	0.001
No	212 (87.6)	26 (66.7)	238 (84.7)	

Child plays outside home				
Yes	48 (20.5)	11 (28.2)	59 (21.6)	0.28
No	186 (79.5)	28 (71.8)	214 (78.4)	
Child goes to school				
Yes	31 (12.9)	6 (15.8)	37 (13.3)	0.63
No	209 (87.1)	32 (84.2)	241 (86.7)	
Mother smokes				
Yes	71 (29.3)	13 (33.3)	84 (29.9)	0.61
No	171 (70.7)	26 (66.7)	197 (70.1)	
Exposure to passive smoking¶				
Yes	161 (66.8)	29 (74.4)	190 (67.9)	0.59
No	80 (33.2)	10 (25.6)	90 (32.1)	
Potential for father's occupational exposure to lead††				
Low	164 (67.8)	18 (47.4)	182 (66.2)	0.008
Moderate-High	73 (30.8)	20 (52.6)	93 (33.8)	
Mother's hobbies with potential Pb exposure‡‡				
Yes	10 (4.1)	2 (5.1)	12 (4.3)	0.78
No	232 (95.9)	37 (94.9)	269 (95.7)	
Father's hobbies with potential Pb exposure‡‡				
Yes	73 (30.2)	14 (35.9)	87 (31.0)	0.47
No	169 (69.8)	25 (64.1)	194 (69.0)	

Note: Missing data in some variables.

† Bottled water, Springs.

‡ For cooking or serving food

§ Child seen eating clay, dirt, paint, plaster, or material from the floor.

|| Outside home, such as playground, street, parking lot, or garden.

¶ Any smoker (father, mother, or other resident) at home.

†† Based on job title.

‡‡ Hobbies such as painting, hunting, or fishing.

Table 4. Logistic regression analysis: Adjusted odds ratio (OR) and 95 % confidence intervals (CI) for potential risk factors for lead poisoning (Blood lead level ≥ 10 ug/dl) among children 1-3 year old

<i>Risk factors</i>	OR (95% CI)
Father's occupation (ref. Non-manual)	
Manual	4.74 (1.82 – 12.31)
Season (ref. Winter)	
Spring	1.07 (0.22 – 5.22)
Summer	4.39 (1.15 – 16.81)
Fall	2.88 (0.94 – 8.84)
Age of building (ref. ≤ 20 years)	
> 20 years	2.01 (0.88 – 4.60)
Traffic jam in area (ref. Rarely)	
Often/Always	4.59 (1.61 – 13.06)
Use hot tap water for cooking (ref. No)	
Yes	3.96 (1.17 – 13.44)
Ever applied kohl on child (ref. No)	
Yes	2.40 (0.92 – 6.28)
(n = 244; χ^2 (8 degrees of freedom) = 45.76; P < 0.001)	

blood lead level

