Bull. Environ. Contam. Toxicol. (1993) 50:730–735

Environmental Contamination and Toxicology

Lead Exposure among School Children in Riyadh, Saudi Arabia: A Case-Control Study

Jamal S. Jarallah,[1] Kamal M. Noweir,[2] Sulaiman A. Al-Shammari,[1] Iman A. Al-Saleh,[3] Mohammed A. Al-Zahrani,[4] and Mohammed H. Al-Ayed[4]

[1]Department of Family and Community Medicine, College of Medicine, King Saud University, Riyadh, Saudi Arabia; [2]High Institute of Public Health, Alexandria University, Egypt; [3]Biological and Medical Research Department, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia, and [4]General Directorate of Preventive Health, Ministry of Health, Riyadh, Saudi Arabia

In the Kingdom of Saudi Arabia the city roads and highways have witnessed a phenomenal rise in vehicular traffic in the last 20 years. The number of registered cars has likewise increased substantially from 774, 000 in 1978 to 4, 950, 466 in 1990 (the statistical book, Ministry of Interior, 1990). The concentration of lead in the gasoline used in Saudi Arabia is 0. 42 gpb/1. (Metrological and Environmental Protection Administration (MEPA, 1985). This is similar to the maximum permissible levels of 0.4 gpb/1 in the United Kingdom, but much higher than the 0.15 gpb/1 in West Germany (Harrison and Laxan 1982). The atmospheric lead concentration in Jeddah city was found to be 3.38 ug/m of air (MEPA, 1985) in certain heavy traffic areas, and this is higher than the air quality guideline of 0.5 - 1.0 ug/m for Europe (WHO 1987).

Children are known to be at higher risk for more sensitive absorption and toxicity to lead. In Saudi Arabia, a recent survey of lead levels in air and in the blood of school children in Jeddah, showed that the blood lead levels were at the threshold which can cause adverse health effects (MEPA, 1985). More recently Ahmed et al (1988) found that the hair lead concentrations in children in four cities in Saudi Arabia below the toxic levels, however the atmospheric lead concentrations were not measured simultaneously. The present study was undertaken to evaluate the health hazards related to lead in school children in different areas in Riyadh City. The study is essentially an environmental as well as a biological one.

MATERIALS AND METHODS

The study was conducted in four primary schools in Riyadh. Three schools were chosen to represent urban, inner-city areas of high traffic density (1. Al-Tathkaryiah, 2. Al-Saudiah and 3. Yahaya Ibn Aktham schools), and a

Send reprint request to Dr. Jamal S. Jarallah at P.O. Box 2925, College of Medicine, King Saud University, Riyadh 11461, Saudi Arabia.

semirural areas of low traffic density (4. Imam Turki Bin Abdullah school) in the outskirt of Riyadh, as control.

The USPHS method (Keenan et al 1963) was used to determine lead levels in air and in biological materials. Air samples were collected by a high volume sampler using fiberglass filters . Each ambient air sample was drawn through the filter, over a period of 24 hours , with an average flow rate of 28-42 feet. The filter was weighed before and after sampling, and the difference in weight as recorded in milligrams. The in total suspended particulate (TSP) concentration per unit of volume was determined as the weight of the sample divided by the total air flow.

A random sample of school children which represents at least 30% of the total number in the first three grades was selected from lists of students in each school. All the school children enrolled in the study were interviewed by primary care physicians who recorded the requested information in a predesigned sheet containing questions on demographic data and symptoms related to lead poisoning and who also performed a brief physical examination with special emphasis on the central nervous system. Data on the behavioural pattern and academic performance was not collected because it was found to be both subjective and time consuming. 5-ml venous blood was collected from each student using a lead - free, sterilized vacutainers with stainless steel needles.

Lead was determined in air and blood by using a varian AA-44 Atomic Absorption Spectrophotometer with a graphite atomizer (GTA-96), according to a standard method (Bordi and Routh 1984). Internal and external quality control procedures were incorporated to monitor and maintain accuracy and reproductibility of the procedure (Taylor 1988).

The data were fed in the main frame computer using the SPSS programme for statistical analysis. Analysis of variance was used for the comparison of lead concentrations in air and blood.

RESULTS AND DISCUSSION

514 school children were included in the study (383 exposed and 131 control), whose ages ranged between 6 and 14 years; and the average age was 8.272 $\pm$ 1.839 years for the exposed was 8.275 $\pm$ 1.848 years for the control group.

The results of blood lead concentration in school children (Table 1) show that the majority (89.7%) of the exposed group had blood levels more than 10 ug/dl, the corresponding figure for the control group was 42.5% ($P<0.01$).

Table 1. Results of blood lead concentrations (ug/dl) in school children in Riyadh City.

Blood Lead conc (ug/dl	Exposed No	Exposed (%)	Control No	Control (%)
<10	38	(10.3)	69	(57.5)
10 -	299	(80.8)	50	(41.7)
20 - 25	29	(7.8)	1	(0.8)
>25	4	(1.1)	-	
Total	370	(100)	120	(100)

Table 2. Comparison of lead concentration in the air and in blood of school children in Riyadh.

Schools	Lead concentration Mean	SD	N	F-value	P-value
Air					
1.	11.5	4.6	28		
2.	10.3	3.0	28	19.32	<0.0001
3.	8.5	3.2	29	on 3.89	
4.	1.2	0.6	8	(degree of freedom)	
Blood					
1.	15.7	4.0	138	59.902	
2.	13.8	3.7	139	on 3.486	
3.	14.2	3.3	93	(degree of	<0.0001
4.	9.9	3.0	120	freedom)	

The atmospheric lead in the vicinity of the four schools have shown a gradient of concentrations according to the location of the school (Table 2). Schools Located in high traffic areas have higher concentrations than the school 4 (control) in lower traffic areas (Table 2). The lowest concentration of 1.2 +0.6 ug/m was recorded near school 4 (the control).

Also, the mean blood lead concentrations have shown a similar trend to the atmospheric lead concentration , except for school 3 where a much higher level was recorded than expected. The mean differences between the atmospheric and the blood lead concentrations in the various school locations , tested by the one way analysis of variance , were statistically significant at the 5% level, while the differences between schools in traffic areas did not reach the 5%level of statistical significance. The control group of children in (school 4) has lowest level of lead concentrations in air and blood.

Recently the Center for Disease Control (CDC, 1991) defined the toxic threshold for children(at which some adverse health effects have been documented) to be as low as 10 ug/dl. The CDC recommended that the goal of lead poisoning prevention activities should be the reduction of children's blood lead levels below 10 ug/dl. In this study the majority of children (80.8%) in the schools located in the high traffic areas (the exposed group) had blood lead concentrations between 10 and 20 ug/dl, while the corresponding prevalence in the control group, (located in low traffic areas is 41.7%). Among the children in the exposed group more than 88%had blood lead concentrations above 10 ug/dl.

This study also showed that the means blood lead concentrations among children in the exposed group (schools 1,2 and 3 - mean levels :15.7, 13.8, and 14.2 ug/dl respectively were not only significantly higher than those of the control group (9.93 ug/dl), but also higher than the reported mean blood lead concentrations (10.7 ug/dl) among elementary school children in some high traffic areas in Jeddah city (MEPA 1985).

The atmospheric lead concentrations in the vicinity of the schools located in high traffic areas as well as the control school were also significantly higher than the urban lead levels (0.5-3.0 ug/m) at sites close to streets in most European cities (WHO 1977). This finding confirms the well established observation that moving away from the centre of the city, is associated with a progressive fall in the atmospheric lead concentrations (WHO1977), and that people who live in close proximity to dense automobile traffic areas are exposed to appreciably higher concentrations than others.

It is evident from this study that there is a positive correlation between the atmospheric and the blood concentrations in all the schools except one (school 3). This relationship exhibits a downward curvilinearity if the range of exposures is sufficiently large, but not at lower levels of exposure (WHO 1977). Also, the data available on blood lead levels in the range found in the general population, suggests that air lead levels of 1 ug/m of air may contribute from 1.0 to 2.0 ug of lead per 100 ml of blood. This may explain the negative relationship between the air lead levels and the blood levels in school 3. Besides, it is also possible that the children of this school are not living in close proximity to the school, but rather in another area of high traffic density.

In view of these findings and based on the recent international environmental and biological standards for lead exposure, it is evident that the levels in lead blood in school children in urban Riyadh are at the threshold which can cause adverse health effects. Indeed in this study symptoms that may be attributed to exposure to lead among school children were noticed more among the exposed group than controls. Since these symptoms occured in only 17.8%, it is difficult to attribute these to elevated blood lead levels. It was not possible to study the behavioural and neuropsychological aspects of exposure of the children to lead because of the limitation in time and facilities.

The ambient air borne lead levels in the heavy traffic areas in Riyadh exceeded international air quality standards. This is probably due to the high concentration of lead in gasoline used in Saudi Arabia. It is advisable that leaded gasoline should be reduced gradually, or even eliminated. Community-based environmental and biological screening of children, mainly in urban areas should be undertaken and results obtained should be the basis for a nationwide environmental intervention. Additionally, detailed study on the neuropsychological, and behavioural effects of lead exposure among children in Saudi Arabia should be encouraged.

Acknowledgment. The authors thank the General Directorate of Research and Planning, Ministry of Health, for the financial support and research grant. We thank Prof. A.M.A. Gader and Prof. M. El-Shabrawi Ali for reviewing the manuscript. The statistical advice of Dr. E. Bomgboye is highly appreciated.

REFERENCES

Ahmed M, Kutbi II, Abulfaraj W, Ahmed P. (1988). Measurement of hair lead concentrations in children of four cities in Saudi Arabia. Env Int 14:237-242.

Boeckx RL. (1986). Lead poisoning in children. Anal Chem 85:274 A-280 A.

Bordi KG, Routh MW. (1984). Trace analysis of lead in blood, aluminum and manganese in serum and chormium in urine by graphite tube atomic absorption spectrophometry. Clin Chem 17:19-26.

Center for Disease Control (1991). Preventing lead poisoning in young children. A statement by the CDC, USA Dept. of Health and Human Services, Atlanta, Georgia.

Harrison RM, Laxan DPH. (1981). Lead pollution causes and

control. London: Champan and Hall; London.
Keenam RG, Bager DH, Dslyxmsn BE, and Hyslopfl (1963). The "USPHS" method for determining lead in air and in biological materials. Am J Indust Hyg 24:48-491.
Meterology and Environmental Protection Administration (MPEA 1985). Lead levels in Air and School Children's Blood, Jeddah, KSA, MPEA, Saudi Arabia.
The Statistical Book (1990). Ministry of Interior, Kingdom of Saudi Arabia.
Taylor A. (1988). The use of internal quality control materials for the preparation of maintenance of reliable methods for the measurement of lead in blood. Frenesius Z Anal Chem 332:732-739.
WHO (1987). Air quality guidelines for Europe, European series, No. 23. WHO regional publications.
WHO (1977). Lead Environmental Health Criteria, No. 3, Geneva.

Received July 28, 1992; accepted December 2, 1992.