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TRACE ELEMENT STUDIES ON KARACHI POPULATIONS PART V: BLOOD LEAD LEVELS IN NORMAL HEALTHY ADULTS AND GRAMMAR SCHOOL CHILDREN

Pages with reference to book, From 150 To 154

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ABSTRACT

Blood lead levels of healthy Karachi population were estimated. Mean levels for males, females, soldiers and school children were 34.4, 31.8, 29.9 and 38.2 ug/dl respectively. About 93% cases of either sex had elevated lead levels, of whom 30% males and 10% females had levels above the safety limits (40ug/dl). Soldiers living in relatively pollution free area though had levels lower than the rest of the population but 91% had levels over 25 ug/dl and only two had acceptable levels. Ninety two percent children showed levels above 25 ug/dl with a large number having levels over 40ug/dl. A very small percentage had normal levels. Pollution by traffic exhaust was assumed to be the principal cause for high levels (JPMA 40:150, 1990).

INTRODUCTION

Lead inspired as small particulate matter is absorbed through the lungs and, of that, in the diet (food and water), about 10% in adults¹ and upto 53% in children² is absorbed by the gastrointestinal tract. Over 94% in adults and 64% in children is accumulated in the bones, the toxic effects being given by that in the soft tissues, principally the brain³. Lead particulate matter tends to concentrate near the ground and is taken up more by children than adults because of their shorter stature. Hence, under a given set of circumstances more lead is taken up by children than by adults. After an exposure to lead, blood levels rise rapidly and relate to recent exposure only as the half -life is only about 18 days, whereas in the brain it is much longer⁴. However, the estimation of blood lead levels is still the most convenient method for an indication of lead status. Blood lead levels of 120 ug/dl in adults and 80 ug/dl in children can be critical⁵ while those above 100 and 60 ug/dl respectively are toxic. However, a range of sub-clinical neurological, physiological, biochemical and psychological effects can occur at much lower levels, including an irreversible loss of I.Q. in children at 25 ug/dl⁶. These effects are discussed in a review⁷. Although safety limits for blood lead levels are still often quoted as being 40 ug/dl for adults and 30 ug/dl for children⁸, the European community decided on an acceptable level of 20 ug/dl⁹ in 1978 with the United States regarding 25ug/dl as being elevated (1985)¹⁰. However, the early signs and symptoms of lead toxicity can be vague and non-specific and there appears to be a continuum of illness from the non-specific CNS symptomatology to the acutely dramatic catastrophe¹¹. As such there is no true safety limit, any lead level has an effect¹². In Karachi the high blood lead levels found in the population are probably due to environmental, occupational, nutritional, socioeconomic and cosmetic factors. There is strong evidence of the contamination of the water supply and fish and other food sources by industrial effluents and the existence of health hazards to workers in lead related industries⁷. A major factor is the uncontrolled emission of exhaust fumes from vehicles running on leaded petrol; the evidence and effects have been well documented⁷. Nutritional

deficiencies of iron, zinc, copper, calcium and phosphorus enhance the absorption of lead from the diet¹³. Childhood exposure to lead is higher in low income areas owing to the environment and lower cleanliness standards¹⁴ and the neurological effects are greater¹⁵. The use of surma, an eye cosmetic, which contains upwards of 100% lead sulphide (89% lead) has recently been shown to be an important factor¹⁶. Levels of upto 80 ug/dl were reported among users, with no clinical effects. Similar results had been reported in U.K. among surma- using Punjabi immigrants together with a death due to encephalopathy¹⁷. Individuals vary greatly in their response to lead: a blood level of 100 mg/dl may kill one person and have no effect on another^{7,18}. There are also racial differences in the response to lead^{7,19,20}. There is little evidence of obvious effects of lead in the general population in Karachi, although certain categories of psychiatric patients have higher lead levels than controls^{21,22}. Perhaps Pakistanis are affected less than Westerners. In November, 1988, the isolation of a low molecular weight protein was reported from red blood cells²³. It chelates with lead and supposedly prevents its toxic actions. The level was low in those with low lead levels or with high lead levels with clear symptoms of lead toxicity. High levels of the protein occurred with high lead levels without toxicity. Investigations in Karachi would be worthwhile.

MATERIAL AND METHODS

Estimations were carried out on whole blood: treatment of samples, standards, controls and blanks, the collection of specimens and precautions taken were as described previously²⁴. Lyophilised human reference whole blood was donated by Nycomed AS, P.O.Box 4284 Torshov, 0401, Oslo 4, Norway. Three sample levels were donated, but only those with the medium and high blood lead levels were used as the lower was below our limits of estimation. Treatment of these were as for the specimens, standards and blanks. Estimations were done by a Pye-Unicam SP2900 atomic absorption spectrophotometer with the following settings:

Filter - clear

Monochromator Band pass : 0.4nm

Reading: 4 second integration

Fuel: Acetylene 1.0 L/min

Air : 5.0 L/min

Wavelength: 217.0 nm

Current: 6mA

Methodology was as described previously²⁴ using whole blood standards for reasons given before²⁵ and aqueous controls. Absorption in whole blood is linear with concentration, and the standard was calibrated by the method of standard additions, the lead concentration being derived from at least three absorbance readings at each of four added concentrations of lead. Zinc did not interfere with absorbance due to lead, even though the former absorbs at 213.9nm which is close to that of lead at 217.0nm, as evidenced by the addition of varying amounts of zinc to samples of known lead concentration. Statistical evaluation of data was by the Wilcoxon Rank Sum Test²⁶ as, in common with most work on trace elements, distributions were non-Gaussian thereby invalidating the student's 't' test.

SUBJECTS

With the exception of the soldiers, blood specimens were from those subjects who had donated blood for the determination of normal ranges for use in the Clinical Laboratories of the Aga Khan University Medical College (A.K.U., unpublished) and for the determination of normal ranges for copper, zinc,

and magnesium for a Karachi population^{24,27}. As far as could be ascertained, all subjects (except for a group of patients below) were normal healthy individuals both of whose parents were of Indo-Pak origin and each was of high socioeconomic status. Subjects were as follows:

- i. The Control Group: The 33 males and 29 females were from among the teaching staff and laboratory technologists of A.K.U. residing in 'posh' areas of the city of Karachi, aged 22-55 (mean 32.9 y) and 17-47 (27.3) respectively.
- ii. 43 soldiers at the Malir Cantonment outside the city of Karachi, aged 22-37 (mean 27.9 y).
- iii. 30 boys and 20 girls attending the Toronto School for Academic Excellence in a 'posh' area of Karachi combined age ranged 3-15 (mean 10.9y), and 108 boys and 82 girls at the Karachi Grammar School in the highly congested city centre, 4-18 (9.1). The children resided in different areas of the city and travelled 10-30 minutes daily each way to school and some did a considerable amount of travelling outside school hours.
- iv. 50 adult outpatients (sex and age unspecified) living near and attending a clinic in the city centre. The nature of their diseases was not expected to influence their lead levels. These complemented the Karachi Grammar School children to a certain degree.

RESULTS

The overall results for the estimation of lead in whole blood standard are given in Table I.

TABLE I. Analytical data concerning the lead concentration in our blood standard.

No. of Calibration curves:	25
Mean lead level	32.05 ug/dl
S.D.	2.75 ug/dl
C.V.	8.59 %
Recovery (mean)	96.25 %

Our results for the analysis of two levels of lyophilised human reference whole blood are in Table II.

TABLE II. Analytical data for the assessment of human reference whole blood.

	Middle Level	High Level
Recommended value (ug/dl)*	37.4	78.8
No. of labs. participating	11	11
Mean Analytical value (ug/dl)	43.9	72.9
Range of values (ug/dl)	27.9 - 45.4	66.2 - 80.0
OUR RESULTS:		
No. of estimations	8	8
Range of values (ug/dl)	38 - 48	75 - 82
Mean Result (ug/dl)	44.6	78.6
S.D. (ug/dl)	4.4	3.8
C.V. (%)	9.87	4.84

*Supplier's recommended value.

The values being 38-48 (mean 44.6 ug/dl) and 75-82(78.6) respectively. The mean values from eleven accredited laboratories were in the range 27.9 - 45.4(43.9) and 66.2-80.0 (72.9), and the manufacturers recommended values were 37.4 and 78.8 ug/dl. Results of the blood lead level estimations in our groups of subjects are given in tables III and IV.

TABLE III. Blood lead levels in the subject groups.

Group	n	Age Range (Mean) yrs	Median (ug/dl)	Mean (ug/dl)	Range (ug/dl)	S.D. (ug/dl)	P	
Controls	M	33	22-55 (32.9)	33.1	34.4	16.4-49.5	7.5	<0.05
	F	29	17-47 (27.3)	30.8	31.8	20.3-49.3	5.75	>0.01 ¹
	M + F	62	17-55 (30.2)	32.8	33.2	16.4-49.5	8.15	
Soldiers	M	43	22-37 (27.9)	30.9	29.9	15.4-39.8	5.0	<0.01 ²
T.S.	M + F	42	3-15(10.9)	39.4	38.2	21.3-52.2*	7.0	<0.01 ³
K.G.S.	M+F	190	4-18 (9.1)	36.9	38.0	10.4-100.9*	14.35	<0.01 ³
Patients	M + F	50		38.9	42.1	25.8-72.9	8.15	<0.01 ³

T.S. = Toronto School for Academic Excellence, Karachi.

K.G.S. = Karachi Grammar School

* = No significant difference between ranges marked

1 = With reference to levels between male and female controls

2 = With reference to levels compared with those for male controls

3 = With reference to levels compared with those for all controls.

TABLE IV. Number (Percentage) of subjects by range of lead level.

Group		n	Below 20 ug/dl %	20-24 ug/dl %	25-39 ug/dl %	40-59 ug/dl %	Over 60 ug/dl %
Controls	M	33	1 (3.0)	1 (3.0)	21 (63.6)	10 (30.3)	0
	F	29	0	2 (6.9)	24 (82.8)	3 (10.3)	0
	M + F	62	1 (1.6)	3 (4.8)	45 (72.6)	13 (21.0)	0
Soldiers	M	43	2 (4.7)	2 (4.7)	38 (88.4)	1 (2.3)	0
T.S.	M + F	50	0	4 (8.0)	24 (48.0)	22 (44.0)	0
K.G.S.	M + F	190	15 (7.9)	1 (0.5)	115 (60.5)	51 (26.8)	8 (4.2)
Patients	M + F	50	0	0	26 (52.0)	18 (36.0)	6 (12.0)

T.S = Toronto School for Academic Excellence, Karachi.

K.G.S. = Karachi Grammar School.

In the latter table a breakdown of the results is given depicting the proportion whose levels were below 20, 20-24, 25-39, 40-59 or above 60 ug/dl. Female controls had significantly lower levels than males; and the soldiers from the Malir Cantonment had significantly lower levels than the male controls. There were no statistically significant differences between the sexes for either group of school children or between the two groups (males plus females in each case), although each group had significantly higher levels than the adult controls. However, although none of the children had higher levels than 60 ug/dl in the Toronto School for Academic Excellence, there were some at the Karachi Grammar School. In our study this was also reflected in the adult patient group from the clinic in the city centre, and levels were somewhat higher overall. A consideration of the blood lead levels among the Karachi Grammar School pupils according to the typical distance travelled each day (Table V)

TABLE V. Blood lead levels according to distance typically travelled each day by K.G.S. Children.

Distance travelled (Kms)	n	Range (ug/dl)	Mean (ug/dl)	S.D. (ug/dl)	P
9 or less	29	12.7-71.6	38.17	12.1	
10-19	100	12.0-100.9	37.6	12.6	> 0.05
20 or more	54	10.4-94.6	37.1	13.9	> 0.05

and according to the place of abode, whether an area polluted by traffic exhaust fumes to relatively low, medium or high extents (Table VI)

TABLE VI. Blood Lead levels according to residence of K.G.S. children.

Area of residence	Relative degree of pollution	n (ug/dl)	Range (ug/dl)	Mean (ug/dl)	S.D. pollution	p
Clifton and Defence	Low	88	12.7-100.9	38.4	14.35	
K.D.A. & P.E.C.H.S.	Medium	48	12.8-71.5	37.4	11.7	> 0.05
North Nazimabad and city center	High	19	10.4-59.6	38.3	10.7	> 0.05

gave insignificant differences in overall lead levels.

DISCUSSION

Of the four metals, copper, zinc, magnesium and lead, the last of these is the most difficult to estimate satisfactorily. Comparison of our results with the results of others (personal communications) for the coefficient of variation (C.V.) in the estimation of lead in our whole blood standard showed that our method is satisfactory and the recovery is good (Table I). Our control subjects, normal healthy individuals living in 'posh' areas of Karachi and therefore in areas of "relatively" low pollution by vehicle exhaust had very high levels according to modern criteria. However, reports from around the world⁷, and results among people living below motorway intersections in U.K. (personal communications) are similar. Our male controls had significantly higher levels than females. About 30% of males and 10% of females had levels above safety limit⁸ of 40 ug/dl about 93% of each sex had elevated levels¹⁰ (above 25 ug/dl) according to modern criteria but if one takes an acceptable limit⁹ of 20 ug/dl only one male complied. Results were significantly lower among soldiers living away from the city in the "relatively" pollution-free Malir Cantonment. Only one, out of the forty-three, had a level just on 40 ug/dl but 39 (90.7%) had levels above 25 ug/dl. Two soldiers had acceptable levels. The tendency towards higher levels in children was reflected in our results. There was no significant difference in levels between the sexes in either group of children, but levels were significantly higher than for controls. There was no statistically significant difference between the two groups of children. The Toronto School for Academic Excellence is situated in a "posh" area of Karachi with the children of affluent parents living in areas situated 10-30 minutes travelling time from the school. Some of them made excursions by road daily after reaching home in the afternoon. Similar to the controls, 92% had lead levels above 25 ug/dl but nearly half had levels above 40 ug/dl and none had levels below 20 ug/dl which is an even more important cut-off point for children⁹. The children at the Karachi Grammar School (K.G.S.) although of similar social background, attended school in the highly polluted city centre. Although the results were not statistically significantly different from the Toronto School children and 92% had levels above 25 ug/dl, 15 (7.9%) did have levels of 20 ug/dl or below and only 31% above 40 ug/dl although five children had levels above the alarming level of 70 ug/dl (one being 100.9) and three between 60 and 70 ug/dl. We included here results from a group of adult out-patients at a clinic in the city centre who also lived in that area. As far as was known, their diseases were not connected with lead toxicity. They complemented the Karachi Grammar School children to a degree by virtue of the fact that they spent all the time in the city centre. Presumably because of this, their blood lead levels, overall, were higher than those of the K.G.S. children. All the patients had levels above 25 ug/dl, almost half being above 40 ug/dl of which two (4%) were above 70 and four (8%) at 60-70 ug/dl. A breakdown of the results for the K.G.S. children according to the typical distance travelled each day (Table V) failed to indicate any significant differences in lead levels. Similarly, consideration of the levels according to whether the children lived in an area of relatively low traffic exhaust pollution (Clifton and Defence area), medium (KDA and PECHS) or high (North Nazimabad and city centre areas) also failed to show any significant differences (Table VI).

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