Lead Exposure And Children: Blood Lead Levels in School Children Resulting From Leaded Petrol Use and Increasing Road Traffic in Pakistan

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Acronyms and Abbreviations

ARL	Attock Refinery Limited
BPbL	Blood Lead Level
CNG	Compressed Natural Gas
CFAP	Clean Fuel Action Plan
CT	Capital Territory
gm/L	gram per liter
IQ	
JICA	Japan International; Cooperation Agency
JPMA	Journal of Pakistan Medical Association
mg/gm	Milligram per gram
NEAP	Environmental Action Plan
NEQS	National Environmental Quality Standards.
NRL	National Refinery Limited
Pak-EPA	Pakistan (Federal) Environmental Protection Agency
PEPA 97	Pakistan Environmental Protection Act. 1997
PEPC	Pakistan Environmental Protection Council
PARCO	Pak-Arab Refinery
PJMR	Pakistan Journal of Medical Research
PRL	Pakistan Refinery Limited
SD	Standard Deviation
SPM	Standard Particulate Mattar
TOE	Tons of Oil Equivalent
ug/dL	Microgram per deciliter
ug/gm	Microgram per gram
ug/m^3	Microgram per cubic meter
UNEP	United Nation Environment Program
WHO	World Health Organization

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Mahmood A. Khwaja

Executive Summary

Increasing prosperity and population growths in many developing countries are resulting in accelerated growth in vehicle population and vehicle kilometers traveled. In Pakistan also the number of vehicles have jumped from 0.8 million to about 4.0 million within 20 years showing an overall increase of more than 400 %. Accordingly, the consumption of petrol (motor spirit) has increased from 828,670 metric tons to 1,189,042 metric tons. The high content of lead in petrol is a serious issue, as the end product of it is the release of lead into the environment. In Pakistan, prior to July 2001, lead content in petrol was reported to be as high as 0.35 – 0.84 gram per liter (however, presently all refineries in the country claim to be producing lead-free petrol).The reported lead levels in air (micrograms/cubic centimeter) in different cities of Pakistan are: Karachi (1980 – 81) 0.13 – 0.24; Peshawar (1994 – 95) 0.21 – 0.79; Lahore (1993 – 94) 0.15 – 8.36 & (1999- 2000) 0.89 – 7.85 and Rawalpindi (1999 – 2000) 0.71 – 10.00, indicating the very alarming increase and high levels of lead in the ambient air, at the reported sites and time of monitoring. Children in developing countries with dietary deficiencies are very susceptible to lead poisoning. Special concern of lead poisoning has been the accumulation of experimental and epidemiological evidence suggesting that lead is a neurotoxin and it impairs brain development in children even at levels that were considered safe. Blood lead levels (BPbLs) have been studied in 900 healthy school children (boys & girls), mostly below 15 years of age and belonging to lower income families, in some cities of Pakistan. The overall mean BPbLs (micrograms per deciliter) in three cities were found to be 22.8 +/- 3.30, 19.00 +/- 6.48 and 2.30 +/- 0.19 (rural site). Details of these investigations and government national environment action plan (NEAP), with special reference to clean air by providing clean fuel and taking others air pollution control measures are described and discussed in this paper.

Key words: *Lead exposure, BPbLs, Petrol, Children*

1. Introduction

Lead pollution is one of the most important problems of environmental and occupational origin and is widely regarded as a risk to health. Lead accumulates in the blood, bones and soft tissues and affects the kidneys, liver, nervous system and blood forming organs. The residence times of lead in the body are estimated at 35 days in blood, 40 days in soft tissues, 3 – 4 years in trabecular bone and 16 – 20 years in cortical bone. Several studies throughout the world have indicated that children are especially sensitive to lead because of their greater exposure and as they absorb, retain and show greater damage for a given body burden. Toxic effects of blood lead levels (BPbLs) > 10 in children are summarized in Table 1.Special concern of lead poisoning has been the accumulation of experimental and epidemiological evidence suggesting that lead is a neurotoxin and it impairs brain development in children even at levels that were considered

safe [1]. There is enough evidence to suggest that in many cases, behavioral and developmental problems in children may be linked to exposure to chemicals like lead in the environment. Lead can damage the brain and nervous system and even a low level of lead exposure can cause learning disabilities, intellectual retardation, hearing loss, speech, language, difficulty in concentrating and staying focussed and propensity to violence and other serious health effects in children.

Table 1.Toxic Effects of Lead (ug/dL) in Children

Kidney: atrophy and interstitial nephritis	80-120
Nervous system: overt clinical encephalopathy	80-100
Gastrointesintal: colic	60-100
Formation of blood cells: anemia	20-40
Formation of blood cells: biochemical (enzyme) changes	<10
Nervous system: IQ/learning disruption	<10

Source: IOMC, GE 98-2263, UNEP September, 1998

Researchers have found that even children with safe blood lead levels (BPbL = 10 ugm/dL or less) had significant brain damage. A recent study has indicated that specially, at five years of age, the children experienced a 5.5 point drop in IQ for every jump of 10 ug/dL in BPbL. 73% of the children having even very low BPbLs. showed IQ drop. It was noted that as BPbLs increased from one to 10ug/dL, a child's IQ fell by an average of 7.4 points, a far more decline than was seen with higher BPbLs [2].

In developing countries like Pakistan, children with dietary deficiencies are even more susceptible to lead poisoning. According to 1998 population census, 43.19% (55,042,917 children) of Pakistan population are children below the age of 15 years [3]. They face high risk due to lead exposure resulting, most likely due to leaded petrol use and increasing road traffic in the country.

2. Vehicle Population Growth And Petrol Consumption

In Pakistan, like many developing countries, the increasing prosperity and population growths are resulting in accelerated growth in vehicle population and vehicle kilometers traveled. The road length which was about 94,000 kilometers in 1980 – 81 had increased to 232,000 in 1997 – 98, indicating an overall increase of 147% over 1980 – 81[3]. The number of vehicles have jumped from 0.8 million to about 4.0 million within 20 years showing an overall increase of more than 400 %. The average compound growth of vehicles is about 11%. The number of registered motor vehicles mostly employing leaded petrol has increased from 714,940 in 1990 to 1,167,635 in 1998 (Table 2 & 3). Vehicle population growth rate being highest (27.7%) in Islamabad.

Table 2: Number of Registered Motor Vehicles

Year	Motor vehicles	Buses Trucks	Motor cycles 2x3 wheels
1980	281587	108655	554241
1985	452977	137729	926209
1990	714940	189261	1301611
1995	976977	232690	1818107
1998	1,167,635	2,51,407	2,130,141

Source: Compendium on Environment Statistics Pakistan 1998

Table 3: Vehicle Population Growth Rates (CT/Provinces)

1	Islamabad	21.76%
2.	Balochistan	11.70%
3.	NWFP	10.30%
4.	Punjab	10.20%
5.	Sindh	8.08%

Source: Pak-EPA, Islamabad 2000

The transport sector is the second largest energy consuming sector after the industry, stimulated by increasing use of road transport at the expense of railway system [4]. Projected fuel consumption for transport sector has been estimated at 40,000 tons of oil equivalent (TOE) in 2050 [5]. The consumption of petrol has increased from 828,670 metric tons (1990) to 1,189,042 (1998). According to 1998 – 99 estimates 98.47% of total petrol consumption is in the transport sector [6]. Lead compounds are added in petrol to increase the efficiency of car engines and to prolong engine life by reducing knock. In Pakistan, prior to July 2001, the lead content in petrol (Premier Plus) was 0.35 gram/liter, very high compared to maximum lead contents of 0.00 – 0.15 gram per liter in USA and many European countries. Regular, Super Premier and HOBC were reported to have lead content of 0.42, 0.63 and 0.84 gm/liter, respectively [2,7,8].

The high content of lead in petrol is a serious issue, as the end product of it is the release of lead into the environment.

3. Lead Levels In Ambient Air

A few studies have been reported on lead concentrations in ambient air and dust-fall on some sites in Peshawar, Rawalpindi, Islamabad, Lahore and Karachi [4,9-10]. The reported lead levels in air (micrograms/cubic centimeter; ug/m$^{3)}$ were Karachi (1980 – 81) 0.13 – 0.24; Peshawar (1994 – 95) 0.21 – 0.79 and Lahore (1993 – 94) 0.15 – 8.36. In 1998, a study with 24 hours monitoring on fourteen locations in Rawalpindi & Islamabad was carried out to examine the concentration levels of trace constituents in suspended particulate matter (SPM) and to assess the ambient air quality in the twin city [8]. At nine monitoring locations, lead content in total SPM was found to be in the range 0.25 – 0.98 ug/m3. In the remaining five monitoring locations, with excessive traffic or industrial activity, lead content in SPM was found to be in the range 1.03 – 4.80ug/m^3 The results of another study, carried out in 1999 – 2000, to assess air quality on some sites in Lahore, Rawalpindi and Islamabad are summarized below in Table 4

Table 4:* Lead Concentration (ug/m^3) of Lead in Air of Major Urban Centers

Sampling Sites	Lahore	Rawalpindi	Islamabad
Site 1	6.18	0.71	10.93
Site 2	5.59	2.10	0.96
Site 3	0.89	1.54	
Site 4	2.88	10.00	
Site 5	7.85		

Source: JICA/Pak.EPA, 2000

Note: * Standards/Guidelines: WHO = 0.5-1.0 ug/m3 (Annual averages); USEPA= 1.5 ug/m3 (Quarterly average)

These results indicate a very alarming increase and high levels of lead in the ambient air at the sites and time of monitoring. WHO/USAEPA guidelines/standards [9,10] for lead concentration in ambient air are 0.5 – 1.0 ug/cm^3 (annual averages) and 1.5 ug/cm^3 (quarterly averages), respectively. However, an accurate assessment of ambient air quality of a site/area is difficult without reliable information and comprehensive data on environmental parameters. For a true

comparison with WHO or other guidelines values, a continuous monitoring and measurements of air pollutants is essential requirement and needs to be addressed at the earliest by Pak.EPA.

4. Blood lead Levels (BPbLs) In Study Population.

There are not many studies carried out in the country with specific research and work done on health or other impacts related to air pollutants. A study carried out in 1990 on 232 students (boys & girls of ages between 3 – 18 years) of two schools in Karachi, indicated mean BPbLs for school children as 38.2 +/- 7 ug/dl, (range 10.4 – 52.2 ug/dl) which was considerably higher than the acceptable BPbLs of 10 ug/dl. 92% of the children population studied had BPbLs higher than 25ug/dl, which can cause irreversible mental impairment [11]. Nearly half of the children had BPbLs above 40 ug/dl and none had level below 20ug/dl. Five children had the alarming BPbLs of 70ug/dl. No significant differences in BPbLs were observed, between the two groups or between the males & females in either of the two groups, the length of distance traveled by children and the traffic density of children's areas of residence.[11].

In another study carried out in 1994, five hundred school students (374 boys & 126 girls of ages 11 – 16 years) were selected from three schools in Peshawar and their BPbLs were examined [15]. Mean BPbLs of male & female students were found to be 21.2 +/- 8.15 and 16.8 +/- 4.81 ug/dl, respectively., indicating BPbLs among males to be significantly higher than females. 13% of male students showed BPbLs in the range 31 – 50 ug/dl with no female student's BPbL within this range. In contrast to Karachi, where 98% of the studied children population had BPbLs over 20 ug/dl, in Peshawar 32.6% had BPbLs over this limit, which may be due to much higher traffic activity in Karachi compared to Peshawar [12].

Studies carried out on BPbLs of 400 school going children in Islamabad and Chakshahzad (about 10 kilometers from Islamabad) also indicated children's BPbLs lower than BPbLs observed for the studied children population in Karachi. The results of these two studies are given with some details in Tables 5 & 6.

BPbLs of 230 school students (girls 129 & boys 101 with ages between 5 – 14) from Islamabad were found to be in the range 13 – 32 ug/dl with overall mean BPbL of 22.8 +/- 3.3 ug/dl, in the studied children population [13] However, unlike Peshawar, no significant BPbLs differences were observed between males and females Children [14]. BPbLs of 170 school students (88 boys & 82 girls of ages 13 – 19 years) from

Table 5: Blood Lead Levels (ug/dl) in Study Population – Islamabad

Age group (Years)	Male			Female			Total		
	No	Mean	SD(+/-)	No	Mean	SD(+/-)	No	Mean	SD(+/-)
5	9	21.2	3.2	6	22.1	3.7	15	21.6	3.5
6	9	20.8	2.9	5	21.7	2.9	14	20.9	2.9
7	10	50.6	3.0	16	22.1	4.3	26	21.5	3.6
8	28	24.2	3.7	17	21.8	3.4	45	23.3	3.5
9	14	23.5	3.4	17	21.4	3.8	31	22.3	3.6
10	8	20.8	2.6	13	20.2	2.7	21	20.4	2.6
11	5	27.1	1.0	15	22.5	4.9	20	23.6	3.2
12	7	25.3	3.0	17	24.6	3.5	24	24.8	3.2
13	6	24.7	1.5	12	25.3	5.3	18	25. 1	3.8
14	5	22.1	2.8	11	23.7	4.1	16	23.2	3.6

Source: PJMR, 31(2) 1992

Table 6: Blood Lead Levels (ug./dl) in Study Population – Chakshahzad

Age group (Years)	Male			Female			Total		
	No	Mean	SD(+/-)	No	Mean	SD(+/-)	No	Mean	SD(+/-)
13	16	4.23	0.52	10	1.20	0.19	26	2.74	0.02
14	17	3.22	0.44	16	2.10	0.27	33	2.69	0.21
15	16	2.98	0.43	18	1.55	0.18	34	2.30	0.17
16	9	2.17	0.39	9	1.08	0.20	18	1.66	0.02
17	13	3.64	0.48	12	1.13	0.23	25	2.42	0.21
18	9	2.82	0.65	1	1.24	0.41	19	2.06	0.41
19	8	2.62	0.62	7	1.85	0.47	15	2.27	0.32

Source: JPMA, 45(8) 1995

20 villages around Chakshazad were found to be in the range 0.2 – 8.6 with overall mean BPbL of 2.38 ug/dl. However, like Peshawar, in Chakshahzad also mean BPbL for males (3.22 ug/dl) was found to be higher than mean BPbL for females (1.49 ug/dl). Low levels in females may be due to their less exposure to the outdoor environment because of the cultural reasons. A comparison of BPbLs in the studied children population of Chakshahzad, Peshawar and Islamabad is given in Table 7. BPbLs of the studied population in Chakshazad are not only lower than Karachi but are also significantly lower than Peshawar and Islamabad. Chakshahzad is a rural site having comparatively much lower traffic activity, resulting in lower vehicle exhaust and relatively very low lead levels in and around the area.

BPbLs higher than 10 ug/dl among the children of Karachi, Peshawar and Islamabad are alarming and children in these areas face high risk due to lead exposure which may very likely cause health problems such as those already been mentioned in Table 1.

Table 7: Blood Lead Levels (ug/dL) in Study Population of Peshawar, Islamabad and Chakshahzad

Urban Centers	Number of Male	BPbL Male ug/dL	Number of Female	BPbL Female ug/dL
Peshawar	374	21.2 + 8.15	126	16.8 + 4.81
Islamabad	101	23.05 + 2.8	129	22.5 + 3.90
Chakshahzad	88	3.22 + 0.19	82	1.49 + 0.10

Source: PJMR, 31(2) 1992; JPMA, 45(8) 1995

5. Vehicle Pollution Control Measures/Programs

Air pollution is one of those complex environmental problems where control through reduction at source is considered most desirable and the only way to prevent the health and other damaging impact [15]. Once emitted into the atmosphere, unlike other matrix/media, the recycling or re-use of the emitted products from air is almost impossible. To combat air pollution in the country, government of Pakistan has formulated acts and policies. Pakistan Environmental Protection Act 1997 (PEPA-97) covers air, water, soil and noise pollution, also including hazardous waste disposal and motor vehicular pollution. PEPA.97 Section 11, sub-section (1) strictly prohibits discharge or emission of any air pollutant in an amount, concentration or level of which is in excess of the National Environmental Quality Standards (NEQS). PEPA-97 Section 15, sub-sections 1 to 3 describes regulation of motor vehicles (see Box 1).

Last year, Pakistan Environmental Protection Council (PEPC) approved a National Environmental Protection Action Plan (NEAP) with "Clean Air" as one of the four priority areas of immediate concern. Components of NEAP clean air program include control of vehicular

pollution, industrial emission and indoor air pollution. As part of the vehicular pollution control program, 2,65,000 vehicles (23.7%) have so far been switched over to compressed natural gas (CNG) and over 300 CNG stations set up in the country [7]. Efforts are also being made to promote use of CNG in auto – rickshaws (three wheelers) through motivation and incentive schemes.

Box 1: Regulation of Motor Vehicles PEPA 97 Section 15

Sub-Section (1)
Subject to the provisions of this Act and the rules and regulations made thereunder, no persons shall operate a motor vehicle from which air pollutants or noise are being emitted in an amount, concentration or level which is in excess of the National Environmental Quality Standards, or where applicable the standards established under clause (g) of sub-section (1) of section 6.

Sub-Section (2)
For ensuring compliance with the standards mentioned in sub-section (1), the Federal Agency may direct that any motor vehicle or class of vehicles shall install such pollution control devices or other equipment or use such fuels or undergo such maintenance or testing as may be prescribed.

Sub-Section (3)
Where a direction has been issued by the Federal Agency under sub-section (2) in respect of any motor vehicles or class of motor vehicles, no person shall operate any such vehicle till such direction has been complied with.

6. Lead - Free Petrol in Pakistan.

Under the Clean Fuel Action Plan (CFAP), a phase-wise lead reduction program to provide low and un-leaded petrol in the country was approved in 1999 by PEPC [7]. The main features of the program were:

(a) October 2000 - reduction of lead content to 0.35 gm/L
(b) Introduction of un-leaded petrol in major cities and highways
(c) Reduce lead content to 0.25 gm/L
(d) Reduce lead content to 0.15 gm/L
(e) Introduce un-leaded petrol throughout the country
(f) 2005 – no more leaded petrol in the country.

Pakistan achieved "No More Leaded Petrol" target much ahead of the target time. Since July 2001, three out of the total four refineries in the country i.e. Pak – Arab (PARCO), National (NRL) and Pakistan Refinery (PRL) started producing lead-free petrol and the fourth refinery, Attock Refinery (ARL) started production of lead-free petrol in June, 2002 (16). This is expected to subside environmental lead pollution to some extent. However, there is a need to periodically check the quality of petrol supplied to the users for maintaining its quality and also in view of smuggled petrol into country which may be containing lead.

7. Removal of Lead from Human Body with Vitamin C

Vitamin C, if taken in regular doses, seems to have potential for reducing accumulated lead from human body, as indicated by some recent studies carried out in Malaysia and Pakistan (17). Children (7 – 12 years of age) under study at Karachi were given a 500 mg vitamin C tablet orally after dinner for 24 days. The mean lead concentration in hair, before giving Vitamin C was 12.7 ± 6.6 ug/gm which after treatment with Vitamin C was reduced to 3.9 ± 3.5 ug./gm. The lead concentration of urine samples of the same children were found to be about 45 times higher than

lead concentration before vitamin C treatment. Similar studies (Aug. 2000 – Jan.2002) carried out in Ranau, Sabah in Malaysia also indicated 24 – 54% reduction in lead concentration of children hair after vitamin C treatment.

8. Recommendations

- Formulation of ambient air quality standards and monitoring of air quality which should also include measurements of benzene and other cancer causing aromatics, resulting from the combustion of unleaded petrol.
- Revision of national environmental quality standards for vehicular emissions to include all criteria pollutants.
- Periodic testing of vehicles for emission and quality of unleaded petrol at petrol stations in the country.
- Further promotion of CNG, including its use in public transport.
- Management of fuel price differential to encourage substitution of polluting fuels with cleaner fuels.
- Improvement traffic management.
- Upgrading of road transport infrastructure and improvement of urban planning to minimize travel distance.
- Follow up study on environmental health impacts on children in particular, especially due to lead, to examine the impact of unleaded petrol supply in the country. Average BPbLs among US children fell from 15 ug/dL in 1978 to 2ug/dL in 1999 after lead was banned in gasoline.

Phasing out lead from Gasoline also gives substantial economical benefits to the country. A study carried out in USA estimated economic benefit = US $ 17.2 billion per annum by reducing US population's BPbL by 1ug/dl [2]. With the supply of unleaded petrol, problems of lead poisoning due to lead in the environment have not been completely solved. There are other sources of lead exposure which include old lead pipelines or lead-based solders in water supply systems, old houses/buildings with lead-based paints and lead-based ceramics. There is a dire need to give high priority to further develop and implement policies and measures that facilitate at the earliest a complete lead phase out program in the country.

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