
Chapter 6

Summary & Conclusion

Globally, despite the improvements in environmental policies and significant reductions in world's average population blood lead levels, lead exposure remains a concern for pregnant and lactating women among certain population subgroups at increased risk for exposure; it is true in context to India too. There is increasing awareness that unintended exposures to environmental contaminants, such as lead, adversely affect maternal and infant health, including the ability to become pregnant, maintain a healthy pregnancy, and have a healthy baby.

Lead exposure remains a public health problem for subpopulations of women of childbearing age and for the developing fetus and nursing infant for several important reasons. First, prenatal lead exposure has known influences on maternal health and infant birth and neurodevelopmental outcomes (Bellinger 2005). Research findings suggest that prenatal lead exposure can adversely affect maternal and child health across a wide range of maternal exposure levels. In addition, adverse effects of lead are being identified at lower levels of exposure than previously recognized in both child and adult populations (Canfield et al. 2003, Jusko et al. 2008, Lanphear et al. 2005, Menke et al. 2006, Navas-Acien et al. 2007 and Tellez-Rojo et al. 2006).

Second, bone lead stores are mobilized during periods of increased bone turnover such as pregnancy and lactation. Over 90% of lead in the adult human body is stored in bone (Barry 1975, Barry and Mossman 1970), and may result in redistribution of cumulative lead stores from bone into blood during periods of heightened bone turnover, such as pregnancy and lactation (Gulson et al. 2003, Roberts and Silbergeld 1995). Since bone lead stores persist for decades, women and their infants may be at risk for continued exposure long after exposure to external environmental sources has been terminated.

Umbilical cord whole blood lead collected at delivery has been widely used as a measure of fetal exposure (Harville et al. 2005, Satin et al. 1991 and Scanlon 1971; Rothenberg et al. 1996). Lead readily crosses the placenta by passive diffusion (Goyer 1990 and Silbergeld 1986) and fetal blood lead concentration is highly correlated with maternal blood lead concentration (Goyer 1990).

The present *cross sectional study* entitled “*Study of Lead exposure (heavy metal) in Pregnant women and in Neonates-a possible health hazard*” is based on the quantitative estimation of Lead (Pb) in venous blood of pregnant women (Maternal Blood Lead-MPL) and cord blood of their respective neonates (Cord Blood Lead CPL).

The present study was carried out for the period of five years from January 2007 to December 2011 in the Dept. of Forensic Medicine, Banaras Hindu University, Varanasi. During

this study period a total of 505 blood samples each from pregnant women (maternal venous blood) and their neonates (cord blood) were collected from the three selected sites i.e. Varanasi, Jaunpur and Agra region of Uttar Pradesh, India. The collected blood samples were processed and analyzed for the presence of heavy metal lead (Pb) with the help of Atomic Absorption Spectrophotometer (model Elico 194 double beam).

Further, the relevant socio-epidemiological parameters, personal data and blood lead levels in the studied subjects were correlated to find out their associations/effects with the help of statistical analysis by employing SPSS (statistical packages for social sciences) version-16. “Chi-square test” was used to find out the association between the variables. “One way analysis of variance” (ANOVA) was used to test the significant difference among the mean blood lead levels in different variables of studied subjects. “Binary logistic regression analysis” was also used to find out the significant independent variables and their quantum of contribution for maternal and cord blood lead levels (Jerold 1974).

The study was done in the dept. of Forensic Medicine, Institute of Medical Sciences (IMS), Banaras Hindu University (BHU), Varanasi, India in collaboration with the Dept. of Obstetrics & Gynecology and Dept of Pediatrics, IMS, BHU, Varanasi, India.

The results of present study summarily given point wise here under:

1. The effects of *residential status* on blood lead level of pregnant women and their neonates (MPL and CPL) at all three studied sites:
 - At site I (Varanasi), the mean Maternal Lead Level (MPL) was found highest ($12.56\mu\text{g}/\text{dl}$) in the women living in rural area in comparison to the women from urban areas ($8.90\mu\text{g}/\text{dl}$). In cord blood, similar pattern was found with highest mean CPL ($8.92\mu\text{g}/\text{dl}$) in the neonates of rural women while lowest ($5.98\mu\text{g}/\text{dl}$) in the neonates belongs to urban women.
 - In Jaunpur region the mean MPL was also higher ($11.89 \mu\text{g}/\text{dl}$) in the women from rural region in comparison ($7.65 \mu\text{g}/\text{dl}$) to the urban women. Similarly the mean CPL was higher ($8.36\mu\text{g}/\text{dl}$) in the neonates of rural women and the mean CPL level was found lower ($5.01 \mu\text{g}/\text{dl}$) in neonates of urban women.
 - Similar to Varanasi and Jaunpur, the findings of Agra indicate that the mean value of MPL was higher ($8.18\mu\text{g}/\text{dl}$) in women residing in rural region in comparison to the women ($5.14\mu\text{g}/\text{dl}$) belong to urban region. Similarly CPL is higher ($4.33\mu\text{g}/\text{dl}$) in rural than urban groups ($2.42\mu\text{g}/\text{dl}$).

Conclusively, observations of all three sites show that rural subjects found with high blood Pb levels than urban subjects.

2. The effects of *educational status* on blood lead level of pregnant women and their neonates (MPL and CPL) all three studied sites:
- In Varanasi, the mean Maternal Lead Level (MPL) was found highest ($12.32\mu\text{g}/\text{dl}$) in the women who were illiterate and the lowest mean MPL ($9.18\mu\text{g}/\text{dl}$) was found in the women having their education up to graduation or above. In cord blood (CPL) similar pattern was found with highest mean CPL ($8.98\mu\text{g}/\text{dl}$) in the neonates born to women who were illiterate and lower mean CPL ($6.17\mu\text{g}/\text{dl}$) found in the highest Educational Status groups (Graduate & above). A sharp decrease in the mean value of MPL and CPL levels observed with the enhanced educational status of the women.
 - Like Varanasi, in Jaunpur the mean MPL level was found maximum ($13.05\mu\text{g}/\text{dl}$ and $13.04\mu\text{g}/\text{dl}$) in the women who were illiterate and educated upto 10th standard. Lowest level ($8.19\mu\text{g}/\text{dl}$) was found in graduate women. The mean CPL was higher ($9.78\mu\text{g}/\text{dl}$) in the neonates born to women having their education up to 10th standard and the lower concentration ($5.60\mu\text{g}/\text{dl}$) is observed in the neonates born to women who had their education up to graduation or above.
 - Similar to Varanasi, in Agra the mean MPL was found maximum ($11.58\mu\text{g}/\text{dl}$) in the women who were illiterate and minimum ($5.39\mu\text{g}/\text{dl}$) in graduate women. The mean CPL of neonates was higher ($8.30\mu\text{g}/\text{dl}$) in illiterate group of pregnant women whereas lower CPL ($2.53\mu\text{g}/\text{dl}$) observed in the neonates whose mother had their education up to graduation or above.

Conclusively, pregnant women literacy has effective impact on the blood Pb levels i.e. lower the literacy rate higher the Pb levels in pregnant women and their neonates.

3. The effects of *occupational status* on blood lead level of pregnant women and their neonates (MPL and CPL) all three studied sites:
- The mean MPL at site I was maximum ($12.97\mu\text{g}/\text{dl}$) in the women who were laborer and minimum ($8.32\mu\text{g}/\text{dl}$) in the professional women. Similarly the mean CPL was found highest ($9.50\mu\text{g}/\text{dl}$) in the neonates whose mothers were working as laborer and lowest mean CPL ($5.29\mu\text{g}/\text{dl}$) found in the others group.
 - In Jaunpur region (site II) the mean MPL concentration was highest ($13.89\mu\text{g}/\text{dl}$) in the women who were laborers. This trend is similar as found in Varanasi region. But lowest level ($9.03\mu\text{g}/\text{dl}$) was found in the women who were involved in other works which is similar to the findings from Agra region. Similarly the mean CPL was highest ($10.08\mu\text{g}/\text{dl}$) in neonates of laborer women and lowest in neonates of women who are involved in other works ($5.29\mu\text{g}/\text{dl}$).

- Results from Agra region were different from Varanasi region. The mean MPL was maximum ($6.64\mu\text{g}/\text{dl}$) in the women who were housewives (unemployed) and minimum ($4.63\mu\text{g}/\text{dl}$) in the women who were involved in other works. Similarly the mean CPL was highest ($3.56\mu\text{g}/\text{dl}$) in neonates of housewives group and lowest ($2.11\mu\text{g}/\text{dl}$) in the neonates whose mothers were involved in other works.

Conclusively, the occupation of the women with poor life style, and low hygienic conditions may be some of the reasons of increment of blood lead levels therefore most of the subjects found with high blood Pb level in Laborer group.

4. The effects of *drinking water used* on blood lead level of pregnant women and their neonates (MPL and CPL) all three studied sites:

- The mean Maternal Lead Level (MPL) in Varanasi region was found highest ($13.68\mu\text{g}/\text{dl}$) in the women who use well water for drinking and cooking and lowest MPL ($9.68\mu\text{g}/\text{dl}$) was found in the women having been used tap water. In cord blood similar pattern was found with highest mean CPL ($10.24\mu\text{g}/\text{dl}$) in the neonates whose mothers were using well water for their daily needs whereas the mean CPL was found lowest ($6.61\mu\text{g}/\text{dl}$) in the women those were using used tap water.
- Like Varanasi region, in Jaunpur the mean MPL was found higher ($13.26 \mu\text{g}/\text{dl}$) in the women who use well water followed by hand pump water and tap water having maternal lead levels $10.23\mu\text{g}/\text{dl}$ and $9.99\mu\text{g}/\text{dl}$ respectively. Similarly in cord blood the mean cord lead level was found maximum ($9.61\mu\text{g}/\text{dl}$) in the neonates whose mothers used well water. It was $7.37\mu\text{g}/\text{dl}$ in the neonates whose mothers were using hand pump water and was lowest ($6.84 \mu\text{g}/\text{dl}$) in the neonates of women using tap water as potable.
- In Agra region no woman was using well water. Therefore for this region we monitored only tap water and hand pump water. The mean MPL was found higher ($7.45\mu\text{g}/\text{dl}$) in the women who used hand pump water in comparison to the women ($5.45 \mu\text{g}/\text{dl}$) using tap water. Similarly in cord blood the mean CPL was found maximum ($4.20\mu\text{g}/\text{dl}$) in the neonates of women who used hand pump water and it was $2.56\mu\text{g}/\text{dl}$ in the neonates of women using tap water.

Conclusively, the source of drinking water used has effective impact on the rising of blood Pb levels (MPL and CPL) in pregnant women and their neonates, it is due to the presence of high levels of lead in the superficial ground water(hand pump)and in surface water i.e. well.

5. The effects of *cooking media used* on blood lead level of pregnant women and their neonates (MPL and CPL) at all three studied sites:

- Women of site I, who use Chulha/coal as a source for cooking purpose also have the mean MPL higher ($12.12\mu\text{g}/\text{dl}$) in comparison to the women ($9.57\mu\text{g}/\text{dl}$) using LPG as cooking medium. Similarly the mean CPL was $8.72\mu\text{g}/\text{dl}$ and $6.59\mu\text{g}/\text{dl}$ in the neonates of women those were using Chulha/coal and LPG respectively.
- The study from Jaunpur region also signifies that women using Chulha/coal as a resource for cooking may have the maternal blood lead level higher ($12.53\mu\text{g}/\text{dl}$) in comparison to the women ($8.92\mu\text{g}/\text{dl}$) using LPG as cooking medium. Similarly the mean CPL levels were $8.86\mu\text{g}/\text{dl}$ and $6.15\mu\text{g}/\text{dl}$ in the neonates of women using Chulha/coal and LPG respectively. A sharp increase is observed in the mean value of MPL and CPL levels in the women who use Chulha/coal as cooking medium.
- From Agra region the same trend is viewed. The women who use Chulha/coal as a source for cooking purpose also have the mean blood Pb concentration (MPL) higher ($8.69\mu\text{g}/\text{dl}$) in comparison to the women ($6.10\mu\text{g}/\text{dl}$) using LPG as cooking media. Similarly the mean CPL was $7.29\mu\text{g}/\text{dl}$ and $3.03\mu\text{g}/\text{dl}$ in the neonates of women using Chulha/coal and LPG respectively.

Conclusively, Chulha / coal users' woman had high blood lead levels and also in their neonates than LPG domestic fuel users. The reason may be that Pb is present in coal as natural constituent. During burning the coal, the Pb may be inhaled with smoke by the users (Block et al. 1975).

6. The effects of *maternal age* on blood lead level of pregnant women and their neonates (MPL and CPL) at all three studied sites:
 - In Varanasi the mean Maternal Lead Level (MPL) was found highest ($14.07\mu\text{g}/\text{dl}$) in the women having age >30 yrs and the lowest ($7.05\mu\text{g}/\text{dl}$) was found in the women of age group ≤ 20 yrs. The MPL level increases with the age of the pregnant women. In cord blood similar pattern was found with highest mean CPL ($10.41\mu\text{g}/\text{dl}$) and lowest CPL ($4.50\mu\text{g}/\text{dl}$) in the age groups >30 years and ≤ 20 yrs respectively.
 - Findings from Jaunpur region are similar to the Varanasi region. Maximum mean MPL ($13.90\mu\text{g}/\text{dl}$) and CPL ($10.72\mu\text{g}/\text{dl}$) was found at the age >30 yrs whereas minimum $6.83\mu\text{g}/\text{dl}$ and $4.27\mu\text{g}/\text{dl}$ respectively in MPL and CPL groups was reported in age ≤ 20 years.
 - Results from Agra also indicates that the mean MPL and CPL was maximum (9.57 and $5.47\mu\text{g}/\text{dl}$ respectively) in the women having age >30 yrs but the minimum mean MPL and CPL (4.33 and $2.44\mu\text{g}/\text{dl}$ respectively) were reported in the women of age group ≤ 20 years.

Conclusively, the increment of maternal age has direct effect on the rise of blood Pb levels (MPL and CPL) of the subjects concerned. The reason behind this is “in childbearing age group usually as the age advances gravida/parity also increase, accordingly blood lead levels get influenced.

7. The effects of *number of gravida* on blood lead level of pregnant women and their neonates (MPL and CPL) at all three studied sites:

- In Varanasi the mean MPL is found higher ($14.02\mu\text{g}/\text{dl}$) in the multiparous women (≥ 3 Gravida) and lower ($8.15\mu\text{g}/\text{dl}$) in the nulliparous women (Gravida 1). Similarly the mean CPL was higher ($10.28\mu\text{g}/\text{dl}$) and lower ($5.11\mu\text{g}/\text{dl}$) in multiparous and nulliparous women respectively.
- Similar findings are also found from Jaunpur region with increase of the mean MPLs and CPLs with gravida of the pregnant women. Highest mean MPL was found in the women having Gravida ≥ 3 ($14.15\mu\text{g}/\text{dl}$) while lowest level was found in the women of gravida 1 ($8.20\mu\text{g}/\text{dl}$). Similarly the mean CPL was highest ($10.87\mu\text{g}/\text{dl}$) and lowest ($5.08\mu\text{g}/\text{dl}$) in the neonates of women having Gravida ≥ 3 and Gravida 1 respectively.
- Agra region also confirm the same rulings that the mean MPL and CPL increases with gravida. Multiparous women (Gravida ≥ 3) were having highest ($9.87\mu\text{g}/\text{dl}$) MPL in comparison ($4.15\mu\text{g}/\text{dl}$) to nulliparous women (Gravida 1). Similarly mean CPL was highest ($5.81\mu\text{g}/\text{dl}$) and lowest ($2.00\mu\text{g}/\text{dl}$) in Gravida ≥ 3 and Gravida 1 respectively.

Conclusively, the rising of blood Pb levels (MPL and CPL) is directly proportional to the number of gravida increased.

8. The effects of *number of previous abortions* on blood lead level of pregnant women and their neonates (MPL and CPL) at all three studied sites:

- The mean Maternal Lead Level (MPL) in Varanasi region was found highest ($15.01\mu\text{g}/\text{dl}$) in the women having at least 2 abortions previously whereas the mean MPL was lowest ($9.53\mu\text{g}/\text{dl}$) in the women with no abortion previously. In cord blood (CPL) similar pattern was found with highest mean CPL ($10.86\mu\text{g}/\text{dl}$) in the neonates of women having at least 2 abortions previously whereas CPL was found lower ($6.48\mu\text{g}/\text{dl}$) in the neonates of mothers with no abortion previously.
- Similar to Varanasi region, in Jaunpur region the mean MPL and CPL was found higher ($15.46\mu\text{g}/\text{dl}$ and $12.20\mu\text{g}/\text{dl}$ respectively) in the women with 2 or more miscarriages previously. The MPL and CPL was found lower ($9.35\mu\text{g}/\text{dl}$ and $6.15\mu\text{g}/\text{dl}$ respectively) in the women with no *abortion* previously.

- In the samples from Agra no women was found with more than 2 previous abortions. Therefore they are categorized in two categories only. The results from Agra region confirms the finding of Varanasi region that the MPL and CPL level increases with the history of previous abortion/miscarriages. The MPL and CPL level was found higher ($11.54\mu\text{g}/\text{dl}$ and $7.33\mu\text{g}/\text{dl}$ respectively) in the women with history of 1 or more abortions. The MPL and CPL was found lower ($5.65\mu\text{g}/\text{dl}$ and $2.62\mu\text{g}/\text{dl}$ respectively) in the women with no abortion.

Conclusively, the rising of blood Pb levels (MPL and CPL) is directly proportional to the number of gravida increased and stored lead in bones to get mobilized in blood of pregnant women, it is immaterial whether pregnant women gives birth to a baby or succumb to abortion. Therefore “the number of previous abortion in the studied subjects found directly proportional to the rising of their blood lead level”.

9. The effects of blood lead levels (MPL and CPL) on *gestational period* of pregnant women and their neonate at all three sites.
 - At site I (Varanasi), the mean Maternal Lead Level (MPL) was found highest ($11.69\mu\text{g}/\text{dl}$) in the women having gestational period <37 in comparison to the women ($10.13\mu\text{g}/\text{dl}$) having gestational period ≥ 37 weeks. In cord blood (CPL) similar pattern was found with highest CPL ($8.60\mu\text{g}/\text{dl}$) in the neonates of women having gestational period <37 and lowest ($7.03\mu\text{g}/\text{dl}$) in the neonates of women having gestational period ≥ 37 weeks.
 - In Jaunpur region also the mean MPL was found higher ($13.12 \mu\text{g}/\text{dl}$) in the women having low gestational period while it was quite lower ($9.14 \mu\text{g}/\text{dl}$) in the women having gestational period ≥ 37 weeks. The CPL was also found higher ($9.97 \mu\text{g}/\text{dl}$) in the neonates of women with gestational period <37 weeks while it is lower ($5.88 \mu\text{g}/\text{dl}$) at gestational period ≥ 37 weeks.
 - In Agra region the findings are similar to Varanasi and Jaunpur sites. The mean MPL was found higher ($8.26\mu\text{g}/\text{dl}$) in the women having low gestational period while it was quite lower ($5.61\mu\text{g}/\text{dl}$) in the women having gestational period ≥ 37 weeks. Similarly in cord blood, the mean CPL was found higher ($4.87\mu\text{g}/\text{dl}$) in the neonates of women with gestational period <37 weeks while it is lower ($2.61\mu\text{g}/\text{dl}$) at gestational period ≥ 37 weeks.

Conclusively, the blood Pb levels in pregnant women and their respective neonates found higher in the subjects having gestation period <37 weeks, “higher the blood lead levels in pregnant women there will be lower the gestational period.”

10. The effects of *maternal hemoglobin* on blood lead level of pregnant women and their neonates (MPL and CPL) of all three sites.
- In Varanasi region, the Maternal Lead Level (MPL) was found highest ($11.91\mu\text{g}/\text{dl}$) in the women who have hemoglobin levels $\leq 10 \text{ gm\%}$ in comparison to the women having hemoglobin $>10 \text{ gm\%}$ ($9.12\mu\text{g}/\text{dl}$). In cord blood similar pattern was found with highest mean CPL ($8.41\mu\text{g}/\text{dl}$) in the neonates of women having Hb value $\leq 10 \text{ gm\%}$ and lowest CPL ($6.22\mu\text{g}/\text{dl}$) in the neonates of women having Hb value $>10 \text{ gm\%}$.
 - Data obtained from Jaunpur region also shows that mean MPL was higher ($11.25 \mu\text{g}/\text{dl}$) in the women who have their Hb level $\leq 10\text{gm\%}$ in comparison to the women ($7.63 \mu\text{g}/\text{dl}$) having Hb level $>10\text{gm\%}$. The mean CPL was found higher ($7.93 \mu\text{g}/\text{dl}$) in the neonates of women with low Hb ($\leq 10 \text{ gm \%}$) and lower ($4.90 \mu\text{g}/\text{dl}$) in the neonates of women who had Hb $>10 \text{ gm\%}$.
 - Results from Agra region also reveals that the mean MPL was higher ($7.04\mu\text{g}/\text{dl}$) in women who have their Hb level $\leq 10\text{gm\%}$ in comparison to the women ($4.32\mu\text{g}/\text{dl}$) having Hb level $>10\text{gm\%}$. Similarly the mean CPL is also found higher ($3.51\mu\text{g}/\text{dl}$) in the neonates of women with low Hb ($\leq 10 \text{ gm \%}$) and lower ($2.06 \mu\text{g}/\text{dl}$) in the neonates of women who had Hb $>10 \text{ gm\%}$.

Conclusively, found that higher the blood lead levels in the pregnant women caused anemia (Hb $\leq 10 \text{ gm\%}$).

11. The effects of *intake of Calcium (Ca) & Iron (Fe)* during antenatal period on blood lead levels of pregnant women and their neonates (MPL and CPL) at all three studied sites:
- At site I (Varanasi), the mean Maternal Lead Level (MPL) was found highest ($12.19\mu\text{g}/\text{dl}$) in the women who have not taken Ca & Fe supplement during pregnancy in comparison to the women ($8.91\mu\text{g}/\text{dl}$) those were having Ca & Fe as supplement during pregnancy. In cord blood similar pattern was found with highest mean CPL ($8.82\mu\text{g}/\text{dl}$) in the neonates of women who have not taken Ca & Fe supplement during pregnancy and lowest CPL ($5.90\mu\text{g}/\text{dl}$) in the neonates of women who had Ca & Fe supplement during pregnancy.
 - In Jaunpur region also the mean MPL was found higher ($12.07\mu\text{g}/\text{dl}$) in the women who have either not taken the Ca & Fe as supplement or taken in low doses. The concentration was lower ($7.99 \mu\text{g}/\text{dl}$) in the women who regularly take Ca/Fe as supplement during pregnancy. Similarly the mean CPL was higher ($8.77 \mu\text{g}/\text{dl}$) in the neonates of women who have not taken Ca & Fe as supplement regularly in comparison to neonates of women ($4.82 \mu\text{g}/\text{dl}$) having Ca & Fe as supplement continuously.
 - Same trend were observed at Agra where the mean MPL was found higher ($8.07\mu\text{g}/\text{dl}$) in the women who have either not taken the Ca & Fe as supplement or taken in low doses.

The concentration was almost half ($4.79\mu\text{g}/\text{dl}$) in the women who regularly take Ca & Fe as supplement during pregnancy. Similarly the mean CPL was higher ($3.96\mu\text{g}/\text{dl}$) in the neonates of women who were not having Ca & Fe as supplement regularly in comparison to neonates of women ($2.37\mu\text{g}/\text{dl}$) having Ca & Fe as supplement continuously.

Conclusively, study established that those pregnant women who do not take/low intake of Ca & Fe as supplement during antenatal period they are having high risk of increasing the blood Lead levels in pregnant women and their neonates (MPL and CPL).

12. The effects of maternal and cord lead levels on *fetal growth- birth weight* (B Wt.) at all three studied sites:

- At site I (Varanasi), the mean Maternal Lead Level (MPL) was found highest ($12.11\mu\text{g}/\text{dl}$) in the women who delivered baby with low birth weight in comparison to the women ($9.71\mu\text{g}/\text{dl}$) who delivered a baby $\geq 2.5\text{kg}$. In cord blood similar pattern was found with highest mean CPL ($8.54\mu\text{g}/\text{dl}$) in the neonates with low birth weight and lowest ($6.75\mu\text{g}/\text{dl}$) in the neonates having B Wt. $\geq 2.5\text{kg}$.
- In Jaunpur the mean MPL was higher ($12.75 \mu\text{g}/\text{dl}$) in women who have delivered a baby having birth weight $< 2.5 \text{ kg}$. and the mean MPL was found lower ($8.49 \mu\text{g}/\text{dl}$) in the women having delivered a baby with birth weight $\geq 2.5\text{kg}$. In cord blood also, the mean CPL was higher ($9.21\mu\text{g}/\text{dl}$) in the neonates with low birth weight in comparison to the neonates ($5.56 \mu\text{g}/\text{dl}$) with normal or more birth weight i.e. $\geq 2.5\text{kg}$.
- It also be concluded from the data of Agra region that the mean value of MPL was higher ($8.33\mu\text{g}/\text{dl}$) in women who delivered a baby with birth weight $< 2.5 \text{ kg}$. and the mean MPL was found lower ($5.05\mu\text{g}/\text{dl}$) in the women who delivered a baby with birth weight $\geq 2.5\text{kg}$. The same trend was observed in cord blood with higher mean CPL ($4.36\mu\text{g}/\text{dl}$) in the neonates of low birth weight ($< 2.5\text{kg}$) in comparison to the lower mean CPL ($2.40\mu\text{g}/\text{dl}$) found in the neonates of birth weight $\geq 2.5\text{kg}$.

Conclusively, found that “higher the blood Pb levels (MPL & CPL) retards the fetal growth i.e. reduces the birth weight (B Wt.)”.

13. The effects of maternal and cord lead levels on *fetal growth- crown heel length* (CHL) at all three studied sites:

- In Varanasi the mean Maternal Lead Level (MPL) was found highest ($11.72\mu\text{g}/\text{dl}$) in the women having delivered baby with low Crown Heal Length (CHL) in comparison to the women ($9.60\mu\text{g}/\text{dl}$) who delivered a baby having CHL $\geq 48\text{cm}$. In cord blood (CPL) similar pattern was found with highest CPL ($8.32\mu\text{g}/\text{dl}$) in the neonates with CHL $< 48\text{cm}$ and lowest CPL ($6.64\mu\text{g}/\text{dl}$) in the neonates with CHL $\geq 48\text{cm}$.

- Similarly in Jaunpur region, it is observed that the mean MPL is found higher (12.02 $\mu\text{g}/\text{dl}$) in the women who delivered a baby with CHL $<48\text{cm}$ while it is lower (8.46 $\mu\text{g}/\text{dl}$) the mother of the neonate having CHL $\geq48\text{cm}$. Similarly the mean CPL concentration was 8.90 $\mu\text{g}/\text{dl}$ and 5.22 $\mu\text{g}/\text{dl}$ in the neonates with CHL $<48\text{cm}$ and $\geq48\text{cm}$ respectively.
- In Agra region the mean MPL is found higher (7.15 $\mu\text{g}/\text{dl}$) in the women who delivered a baby with CHL $<48\text{cm}$ while it is lower (5.66 $\mu\text{g}/\text{dl}$) in the mother of the neonates having CHL $\geq48\text{cm}$. Similarly the mean CPL concentration was 3.59 $\mu\text{g}/\text{dl}$ and 2.95 $\mu\text{g}/\text{dl}$ in neonates with $<48\text{cm}$ and $\geq48\text{ cm}$ CHL respectively.

Conclusively, found that “higher the blood Pb levels (MPL & CPL) retards the fetal growth i.e. reduces the crown heel length (CHL)”.

14. The effects of maternal and cord lead levels on *fetal growth- head circumference* (HC) at all three studied sites:

- In Varanasi the mean Maternal Lead Level (MPL) was found highest (10.87 $\mu\text{g}/\text{dl}$) in the women who delivered baby with less Head circumference (HC) in comparison to the women (8.54 $\mu\text{g}/\text{dl}$) who delivered a baby having HC $\geq36\text{cm}$. In cord blood similar pattern was found with highest mean CPL (7.71 $\mu\text{g}/\text{dl}$) in the neonates with HC $<36\text{cm}$ and lowest CPL (5.60 $\mu\text{g}/\text{dl}$) in the neonates with HC $\geq36\text{cm}$.
- The findings from Jaunpur region also indicates that higher mean MPL (10.75 $\mu\text{g}/\text{dl}$) will be found in the women who delivered a baby with HC $<36\text{ cm}$ while it is lower (10.29 $\mu\text{g}/\text{dl}$) in the mother of neonate having HC $\geq36\text{ cm}$. Similarly the mean CPL concentration was 7.62 $\mu\text{g}/\text{dl}$ and 7.21 $\mu\text{g}/\text{dl}$ in the neonates with HC $<36\text{ cm}$ and $\geq36\text{ cm}$ respectively.
- It is observed from Agra region that mean MPL was higher (6.36 $\mu\text{g}/\text{dl}$) in the women who delivered a baby with HC $<36\text{ cm}$ while it was slightly lower (6.04 $\mu\text{g}/\text{dl}$) in the neonate having HC $\geq36\text{ cm}$. Similarly the mean CPL were 3.43 $\mu\text{g}/\text{dl}$ and 2.77 $\mu\text{g}/\text{dl}$ in the neonates with HC $<36\text{ cm}$ and $\geq36\text{ cm}$ respectively.

Conclusively, found that “higher the blood Pb levels (MPL & CPL) retards the fetal growth i.e. reduces the head circumference (HC).

15. Finally, by using Binary logistic regression analysis to find out the significant independent contribution for Maternal and cord lead levels (MPL & CPL) by combining all the studied variables used for socio-epidemiology, pregnant women and their neonates of three sites.

- In pregnant women, this test highlights that 41.9% variation of MPL is explained by the *Gravida* of pregnant women alone. By adding another variables i.e. *Site*, the percent variation is increased upto 52.6%. Similarly by adding the consecutive significant

independent variables in the above model i.e. Residential status, Ca & Fe intake, Maternal age, CHL and HC of the neonates, Gestational age the above percentage variation successively increased 58.8, 61.1, 63.8, 65.7, 66.7 and 67.6 respectively. Further, by adding all the remaining significant independent variables (i.e. Number of previous abortion, maternal Hb, Birth weight of the baby, sources of drinking water and cooking media used, education and occupation status of the Pregnant women) in the model, this percent variation found increased with 1.2% only i.e. up to 68.8.

- In neonates, this test highlights, that 48.7% variation of CPL is explained by the *Gravida* of pregnant women alone. By adding the next variable i.e. *Site*, the percent variation is increased up to 56.2%. Similarly by adding the consecutive significant independent variables in the above model i.e. Ca & Fe intake, drinking water, gestational age, maternal age, history of previous abortion and maternal hemoglobin upto step eight, the above percentage variation increased up to 59.2, 62.1, 64.2, 67.2, 68.6 and 69.4 respectively. Further, by adding all the remaining significant independent variables (i.e. CHL, HC, B Wt. of the baby, residential status, sources of cooking media used, education and occupation status of the Pregnant women) in the model, this percent variation found increased with 3.3% only i.e. up to 72.7.

Although lead exposure remains an important potential risk to the fetus, until now, little emphasis has been placed on developing guidelines for prenatal health care providers and women of childbearing age. In India, there are currently no national recommendations or guidelines by any obstetric, family practice, pediatric, or nursing groups that cover lead risk assessment and management during pregnancy and lactation.

Because no national recommendations exist, the Centers for Disease Control and Prevention (CDC), local and state lead poisoning prevention programs have not been able to consistently respond to concerns from medical providers about when to test pregnant or lactating women for lead exposure and how to manage pregnant or lactating women who have been identified with lead exposure above background levels that have resulted from widespread ambient lead contamination and naturally occurring lead in the earth's crust.

In light of present research work and its outcome in general, it is felt that for the health betterment of pregnant women and their newborn infants, the implementation of some of the suggestions/recommendations are needed as detailed hereunder:

1. Campaign for special and regular Health education and Awareness programs regarding the health for general public on potential adverse effects of toxic heavy metal (i.e. Pb) should be organized frequently by Govt. /NGOs.

2. Blood lead level estimation of all pregnant women in India is not recommended. Therefore, Routine blood investigation for lead load in pregnant women should be recommended in clinical settings that serve populations with identified risk factors for lead exposure.
3. Estimation of blood lead level should be performed if a single risk factor is identified at any point during pregnancy e.g. H/o previous abortion, multigravida, low Hb, pregnancy at advanced age etc.
4. To know the toxicological threshold of Pb (BLL $\geq 5 \text{ } \mu\text{g/dl}$) for adverse health effects in women of childbearing age group and in there outcomes the routine & follow-up blood investigation is recommended for clinical decision-making purposes to get healthy newborn infant.
5. Periodic & Regular monitoring of heavy metals loads in drinking water resources should be done by appropriate authorities.
6. Region and state wise the environmental pollution control board, should collect the information on environmental burden of heavy metals, periodically.
7. Stringent legislation to reduce industrial Heavy metals emission to safe guard human health hazards and environment is needed.

