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Research article

Lead exposure of Bangladeshi women at childbearing age: Does mother's education reduce fetal risk factors?

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ABSTRACT

Lead is one of the oldest toxins existing in the environment that can affect almost all organs of the body without any noticeable symptom. Depending on its concentration in the body, lead may cause lower IQ level, autism, abnormal pregnancy outcome, abortion, and increased involvement in crime. As lead can cross the placental barrier and affect the fetus, pregnant women, fetuses, and children are more vulnerable to lead poisoning because of rapid bone mobilization and neurodevelopment. Therefore, this study aimed to evaluate the awareness of lead exposure among Bangladeshi women of childbearing age on the basis of their educational level. A questionnaire survey was conducted among the participants comprising both less-educated ($n = 62$) and more-educated ($n = 52$) women. Data were analyzed using SPSS (version20), and relevant statistical techniques were used to draw the results. The findings showed highly significant differences between the two groups in relation to economic condition, lifestyle, residential location, use of traditional cosmetics, and food habit ($p < 0.0001$). Although the more-educated women claimed that they were aware of the harmful effects of lead, as opposed to the less-educated women not being aware ($p < 0.0001$), they failed to substantiate their claim because this was not reflected in their everyday practices as revealed by the 'previous birth outcome records' of their fetuses. This indicated that their knowledge or awareness of lead, particularly its sources and detrimental effects, remained superficial, and their educational background had no statistically significant difference with respect to the awareness of lead toxicity ($p = 0.103$). Given that a mother's exposure to lead can directly affect her fetus, this study bears high significance, as the results imply that if women are aware of the sources of lead and the consequences of lead poisoning, the body burden of lead could be reduced in the next generation, which, in turn, would have a high economic impact.

Keywords: Lead Pb, awareness, women at child bearing age, fetus, education

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INTRODUCTION

Lead is one of the widely distributed toxicants in the environment[1] via water, soil, air, dust, food, cosmetics, and traditional/herbal medicines.[2] It is known to exert acute and chronic toxic effects on almost all the organs of the body at higher concentrations, including neurotoxicity, toxicity in reproductive and endocrine systems, and nephrotoxicity.[2,3] Furthermore, researchers have found that even at a very low dose ($<2\mu$g/dl), without any noticeable syndrome,[4] lead may cause lower IQ levels, memory problems, inattentiveness, lack of concentration, poor fine motor skills, and difficulty with planning.[5–9]

Lead has a half-life of 40–60 days in the blood. From the blood, it initially appears in the cells of the kidneys and liver, and is then gradually redistributed and deposited in the bone,[10] teeth,[11] nail,[12] hair,[13] and brain.[14] The capacity for lead excretion is very limited, and even a slight increase in daily intake may produce a positive lead balance.[10] Lead accumulates in the bone for decades.[15] During bone remodeling, such as in growing children or pregnancy, it can be transferred again from the bone to the blood.[16]

It is evident that lead can cross the placental barrier and affect the fetus.[16–19] Therefore, the mother's knowledge and awareness of the sources and detrimental effects of lead is very important because exposure through the mother's lifestyle will result in the accumulation of lead, from the bone to the blood, which could be passed on to her fetus through the placenta. Moreover, it is evident that lead exposure in children and fetuses is more dangerous than the later exposure because of their rapid development of the central nervous system (CNS).[5]

With the phase-out of lead in petrol in Europe from the mid-1980s, and from other parts of the world,[20] it was expected that lead-related concerns would be diminished. However, in reality, lead still remains a widespread environmental pollutant and a concern for public health. In many developing countries, lead is still added to paints, pigments, traditional cosmetics and medicines, and other consumer products such as spices, food colors, and canned tins.[21] Therefore, the people of Bangladesh are under the threat of lead burden from different known and hidden sources. This study focused on the women of Bangladesh, with different educational levels, at their childbearing age. Although the Government of Bangladesh has made primary and secondary education compulsory and free for girls, most of them are not able to complete their education for social and economic reasons. Moreover, with an exam-centric education system, a good proportion of them tend to focus on passing the examination; thus, their lack of awareness of these important issues still persists.

Although the Government of Bangladesh has set a policy for the mitigation of lead through the restricted use of leaded petrol and paint, a number of studies in Bangladeshi adults and children have shown an increased body burden of lead ($>5\,\mu$g/dl) from different sources.[22–26] However, no study has been conducted to evaluate the knowledge, attitude, and practices among the women of developing countries at childbearing age to mitigate the 'silent killer' lead.

Therefore, this study aimed to assess the knowledge about the sources and detrimental effects of lead among more- and less-educated Bangladeshi women at childbearing age, and to evaluate their practices to mitigate lead poisoning in their fetuses. It is expected that the findings of this study would help policy makers to rethink and undertake necessary measures to eradicate the sources of lead exposure and to increase the awareness of the detrimental effects of lead among women of less developed and developing countries.

MATERIALS AND METHODS

Research design

This study was designed to assess the knowledge, attitude, and practices with lead among the Bangladeshi women at childbearing age. Participants were divided into two groups on the basis of their educational level. Women who did not obtain any education or who were educated only up to secondary levels were classified as less-educated group (group 1). Women who received education above the secondary levels were classified as more-educated group (group 2). The survey was conducted using a paper-based structured questionnaire. The respondents included married, unmarried, and pregnant women of childbearing age.

Development of the questionnaire

The structured questionnaire was designed to identify the potential sources of lead exposure in the study participants. It was set by reviewing various studies on the following sources of lead exposure:

hobbies involving gardening, pet handling, and painting;[27] location of homes near the highway, a busy street, or a vehicle depot area;[28] use of cosmetics such as kajal and lipstick;[29–31] intake of spices and food color, e.g. turmeric, saffron;[32] intake of canned food;[33,34] intake of animal fat;[35,36] production and consumption of tea,[37] tobacco, betel leaf, and sadapata;[38] and use of traditional or herbal medicine.[39]

This survey was approved by the Ethics Committee of the Department of Pharmacy, BRAC University, Bangladesh. Pre-testing of the questionnaire was conducted using10 participants (five each from the more-and less-educated group). The validity of the questionnaire was tested by a statistician to assess the rigor of the study.

Determination of the sample size

After a thorough review of the literature, we found that no study conducted so far has specifically assessed the knowledge on the sources and detrimental effects of lead, and the practices to mitigate this effect among women (including women of Bangladesh). Therefore, there were no data available to determine the sample size or even to calculate the 'power' of the study, which can help demonstrate a statistically significant finding at the 5% level of significance ($p < 0.05$). Many researchers have found that samples with less number of participants ($n = 10–30$) may even have some practical advantages, which include simplicity, easy calculation, and the ability to test hypotheses.[40–42] Therefore, it can be argued that a total of 114participants, in two groups, is an adequate sample size for this study, and would be free from any small-sample size bias from a statistical point of view.

Participant recruitment and data collection

Participants were recruited for this study by using a simple random sampling technique. They originated (migrated) from different parts of Bangladesh but lived in Dhaka city, particularly in the slum areas of Mohammadpur, Mohakhali, Gulshan, and Adabor. The purpose and importance of the study were explained to the participants before the commencement of the survey. Those who agreed to participate signed a consent form. The more-educated participants were assessed by using a self-administered questionnaire. In contrast, the less-educated participants were assessed by using the questionnaire filled out with the help of the researcher(s). The pregnancy outcome data were based on previous birth outcome records collected from the participating mothers.

Statistical analysis

Statistical analysis was performed using SPSS, version 20. The statistical package was used to compute descriptive statistics for continuous variables. Pearson's χ^2 test was used to find the differences between the two groups, in terms of frequencies, across various categories of a particular variable.

RESULTS

The total number of participants selected for this study was 114. In both less-educated ($n = 62$) and more-educated ($n = 52$) groups, the average age of the participants was 22 years (range 15–35 years in group 1 and 18–33 years in group 2). The majority of the participants were Muslims (92%). Most participants from the less-educated group were either housemaids or garment workers with low family income. In contrast, the participants from the more-educated group were either students, housewives, or engaged in both government and private services with high family income. Demographic and related information about the participants is presented in Table 1.

Table 2 summarizes the participants' lifestyle data, particularly focusing on their everyday exposure to lead from different potential sources. Among the respondents, only 16% from group 1 were found to live in painted houses, whereas all the participants from group 2 reported that they dwelt in such houses. Surprisingly, it was found that only 22% of the participants from group 2knew that the paint contained lead ($p < 0.159$). The difference between the groups was statistically highly significant ($p < 0.0001$) in relation to the location of their homes, particularly their proximity to the highway or a busy street where the availability of lead could be higher ($p < 0.0001$).

A highly significant difference was observed (Table 2) between the groups in terms of hobby-related lead exposure, e.g. gardening (using pesticides), pet handling (exposure to dust and soil), and glass painting ($p < 0.01$). The use of traditional cosmetics and the habit of eating betel leaf/zarda/sadapata were observed to be significantly higher in group 1 ($p < 0.001$), whereas the habit of drinking tea or coffee and the consumption of ayurvedic or herbal medicine were found to be higher in group 2

Table 1. Demographic information of the participants.

Parameters		Less-educated group ($n = 62$) *n* (%)	More-educated group ($n = 52$) *n* (%)
Age (years)	Average (range)	22 (15–35)	22 (18–33)
Income (Taka)	0–5000	41 (66.3)	35 (67.3)
	5000–10,000	21 (33.7)	7 (13.4)
	Above 10,000	–	10 (19.2)
Religion	Muslim	57 (91.9)	48 (92.3)
	Hindu	3 (4.8)	4 (7.7)
	Christian	2 (3.2)	–
Education	Uneducated	18 (29.0)	–
	Primary	38 (61.2)	–
	Secondary	6 (9.6)	–
	Above secondary	–	52 (100.0)
Employment	Employed	39 (62.9)	17 (32.6)
	Unemployed	23 (37.0)	35 (67.3)
Marital status	Married	38 (61.2)	13 (25.0)
	Unmarried	24 (38.7)	39 (75.0)

($p < 0.029$). However, no significant difference was found between the groups in relation to the consumption of canned food and food color ($p < 0.054$).

Women from less-educated background were found to have significantly lower or no knowledge about the sources and adverse effects of lead than those from more-educated background ($p < 0.0001$). However, it was interesting to note that although the participants from the more-educated group knew that lead is a harmful substance for the body, they lacked knowledge about its sources or the extent of its toxicity. Only a few participants (22.8%)from the more-educated group mentioned about their exposure to some sources of lead, while most of the participants from both the groups did not have any knowledge about the primary and potential sources of lead ($p = 0.109$).

Only a few pregnancy outcome data were available from the survey. The birth outcome data were collected from the participating mothers who had at least one parity. Some key variables included in the data were mother's parity, infant's sex, gestational age, premature rupture of membranes (PROM), and birth weight, all of which reflected the outcome of the mothers' everyday practices with lead. Apart from PROM, no statistically significant difference was observed (Table 3). Different statistical techniques such as *t* test, Mann–Whitney *U* test, and χ^2 test were used, depending on the variables being considered. Table 3 summarizes the results for comparison of pregnancy outcomes between the two groups.

Table 2. Participants' exposure to lead from hidden sources in everyday life.

Hidden sources of lead	Group 1 (% yes)*	Group 2 (% yes)	Pearson's χ^2**, *p*
Hobbies and occupations (related to lead)	37.5 (gardening) 0 (pet handling) 6.2 (glass painting)	6.8 (gardening) 15.9 (pet handling) 0 (glass painting)	15.58, $p < 0.004$
Living in a house built before 1978	25.8	53.9	60.19, $p < 0.027$
Use of cosmetics	33.9 (kajal) 30.6 (lipstick)	98.1 (kajal) 86.5 (lipstick)	50.10, 35.88, $p < 0.0001$
Consumption of canned foods	97.6 (cola drinks, fruit juice, ghee)	88.9 (olive, pickles, fish)	5.82, $p < 0.054$
Drinking tea/coffee	81.0 (1 cup/day) 19.0 (>1 cup/day)	19.1 (1 cup/day) 56.0 (>1 cup/day)	12.42, $p < 0.029$
Eating betel leaf/zarda/sadapata	82.1	50.0	20.10, $p < 0.0001$
Consumption of visible fat	51.6	11.5	37.51, $p < 0.000$
Purchase of food/cosmetics from the local market	100	43	47.24, $p < 0.014$

*Results are expressed as the percentage of respondents who answered 'yes'. **Pearson's χ^2 statistic was used to find the differences between the two groups, in terms of frequencies, across various categories of a particular variable ($n = 62$, $n = 52$). All the tests were performed individually and summarized in the table.

Table 3. Comparison of pregnancy outcomes between less-and more-educated mothers.

Variables	Group 1 ($n = 40$)	Group 2 ($n = 34$)	Test statistic
Mother's age (mean (SD))	20 (3.14)	24 (2.93)	$t = 1.773$; $p = 0.079$
Parity (median (IQR))	3 (2)	2 (2)	$U = 1812$. $p = 0.802$
Type of delivery (yes, n(%))			
Normal	27 (67.5)	12 (35.3)	$\chi^2 = 1.562$; $p = 0.458$
Caesarean	09 (22.5)	19 (55.9)	
Forceps	4 (10)	3 (8.8)	
PROM (yes, n(%))	4 (10)	1 (2.9)	$\chi^2 = 60.19$; $p < 0.027$*
Preterm delivery (yes, n(%))	5 (12.5)	3 (8.8)	$\chi^2 = 0.396$; $p = 0.529$
Gestational age (weeks)(mean (SD))	37.3 (2.0)	39.9 (1.6)	$t = 1.09$; $p = 0.615$
Birth weight(g) (approx. mean (SD))	2939 (559)	3122 (635)	$t = 0.86$; $p = 0.471$

DISCUSSION

This study was conducted on Bangladeshi women of childbearing age ($n = 114$). The participants were divided into two groups on the basis of their educational level (less-educated group and more-educated group), in order to compare their knowledge and attitude towards the sources of lead and the harmful effects of lead poisoning and their practice to mitigate this effect.

It has been found that lead can be accumulated in the bone for decades after it enters the blood due to the mother's exposure to this toxin.[15] During bone mobilization in pregnancy, the accumulated lead can re-enter the blood and can cross the placental barrier, thus affecting the fetus.[16–19] Moreover, researchers have previously proved that prenatal exposure to lead is more dangerous than later exposure.[5] This is because lead can silently cause neurotoxicity at any concentration, which results in lower IQ level, memory problems, inattentiveness, lack of concentration, poor fine motor skills, and difficulty with planning.[5–9] The significance of this study lies in the fact that if women are aware of the sources of lead and the consequences of lead poisoning, the body burden of lead could be reduced in the next generation because lead from the mother's blood can cross the placental barrier and affect the fetus.[16–19]

All the responses of the participants obtained from the questionnaire reflected their knowledge and attitude towards lead. In addition, their practice to mitigate lead exposure was assessed by using the record of their fetal outcome. The participants may have been exposed to lead through soils,[43] fertilizers,[44] dust,[22] or paints.[25] This is not a scenario taking place only in Bangladesh. A recent finding has also shown that lead levels in rice, imported into the USA from Taiwan and China, are between 6 and 12 mg/kg.[44] Moreover, food has been considered as the largest source of lead because of the use of contaminated soil and fertilizers, and solder in food canning.[34,43,45]

Most of the participants in this study were found to use cosmetics such as kajal and lipstick. It has been reported that the main component of kajal is lead sulfide.[29] Careless application of kajal, eye rubbing, and lacrimation may cause absorption of lead through the conjunctiva.[30] Moreover, the permissible limit of lead content in lipstick is 20 Pb/ppm, as recommended by the FDA in 2011. Sometimes adulterated or defective manufacturing procedures of such cosmetics can introduce lead into the ingredients, which enters the body through ingestion.[31] In addition, adulteration of these cosmetics is also very common in the local market of developing countries. The findings of this study showed a significant difference between the two groups in relation to the sources of these shopping items ($p < 0.046$). This is mainly due to the differences in their financial status, but not due to the differences in their awareness of lead, as described below.

A recent study conducted in Bangladesh has reported that packaged turmeric powder contains lead.[46] In a study conducted in Boston, USA,[32] four lead-exposed case reports have been recorded, in which the spices contaminated with lead have been found to be imported from the Indian subcontinent (blood lead level (BLL) range 18–43 μg/dl). The source of this contamination is attributed to the addition of low-cost lead oxide to spices, which is similar in appearance to many spices. Unfortunately, this often remains undetected due to the lack of proper inspection.

Exposure to lead has also been found to occur through the consumption of tobacco,[38] tea,[37] and traditional or herbal medicine.[39] In this study, women from the more-educated group were found to use more herbal medicine than did the less-educated group. In Bangladesh, the cost of herbal medicines is usually higher than that of allopathic medicines. This is, therefore, another indicator by which it can be

predicted that the difference in lead exposure between the groups hardly depends on awareness, rather it is more likely to be associated with people's economic condition.

A seven-fold increase in lead absorption has been reported from diets with high fat content.[35,36] This study found that most of the women from the less-educated background ate visible fat from red meat (51.6%), whereas more-educated women tended to avoid fat intake ($p < 0.0001$). This phenomenon observed in the latter group is not due to the awareness of lead toxicity in visible fat, but rather to their preference to reduce high blood cholesterol levels.

In addition, this study showed that educational level had no statistically significant difference with respect to the awareness of lead toxicity ($p = 0.103$). This is not only the scenario taking place in a developing country such as Bangladesh, but a similar finding has also been observed in the UK. The MaBEL (Mother's and Baby's Exposure to Lead) study was conducted in 2011 to evaluate lead levels in British and South Asian pregnant women in Leeds, UK. Although there was a significant difference in BLLs (higher in South Asian pregnant women) and educational level (generally higher among British pregnant women) between the groups, no significant difference was found with respect to the awareness of lead toxicity (awareness: British (11%) and South Asian (8%); $\chi^2 = 0.19$; $p = 0.663$).[47] Similarly, lack of awareness of lead is also globally prevalent.[48] However, the people in developed countries remain less exposed to environmental pollutants because of the strict implementation of government policies on these products. In Bangladesh, a policy has been set to reduce the exposure to lead; however, it has been observed that there is a lack of policy implementation. Moreover, no prenatal service is available to make the (pregnant) mother aware of environmental pollutants.

Given that lead accumulates in the mother's body and crosses the placenta, previous birth outcome records were collected from the participants to evaluate their practice of avoiding lead in their everyday activities. No significant differences were observed in relation to fetal outcomes except for PROM,[49] which was found to be high among the less-educated participants. The probable physiological explanation for this finding is that the mother's bone remodeling and physiological changes in organ systems take place from 12 weeks of gestation and that lead crosses the placenta from around this time until term. Moreover, there is a continuous transfer of lead that takes place across the placenta to enter the fetal circulation. Once it enters the fetal circulation, lead becomes sequestered in red blood cells to the same extent as that in the mother.[16–19]

This study sheds light on the fact that prenatal exposure to lead is more dangerous than later exposure.[5] Behavioral effects from prenatal exposure to lead have been highlighted in some studies, including the number of 'criminal arrests' in early childhood.[50] A significant association ($p \leq 0.05$) has also been found between prenatal and childhood BLLs(≥ 5 μg/dl, measured biannually from infancy through to 6.5 years)with respect to criminal arrests in adolescence.[51] Moreover, many researchers have found that the rate of increasing intellectual impairment is greater at BLLs < 10 μg/dl.[52] A cost–benefit analysis shows that elevated BLLs are an 'economic drain' on the society, as a result of the relationship between IQ and lifetime earnings.[4] Therefore, increasing awareness of 'lead as a silent killer' among women of childbearing age is very important for the next generation and for the society overall.

LIMITATIONS OF THE STUDY

As the survey was not conducted in rural areas, true reflection of the rural women of Bangladesh could not be captured. Therefore, this study could not analyze the whole scenario of the knowledge and practice of lead poisoning in Bangladeshi women.

CONCLUSION

Exposure to lead is extremely detrimental to human health and can have irreversible long-term health impacts on both adults and children. Bangladesh is a developing country where most of the people live below the poverty line and do not receive appropriate education.[53] The findings of this study showed that irrespective of educational level, none of the women were aware of detrimental environmental pollutants such as lead. More-educated women tend to buy products from regulated shops due to their affluence when compared with less-educated women. Under the circumstances, prevention of unregulated sources of lead poisoning is important. Therefore, development of awareness programs should be designed and implemented with participation from both public and private sectors to ensure the safety of public health. Women should be aware of the fact that the lead deposited in their body through their lifestyle can have harmful effects on their fetuses. Therefore, for people in developed and

developing countries, not only the mother's education but also their awareness of the harmful effects of lead can reduce the risk factors associated with fetal outcome and children's CNS and bone development.

Authors' contributions

SN conceived the study, developed the methodology, and directed the survey and analyzed the data using the SPSS software. RAH conducted the questionnaire survey and performed the data input. Both the authors reviewed the literature, interpreted the results, drafted the manuscript, and read and approved the final manuscript.

Conflicts of interest

Both the authors declare that they have no conflicts of interest.

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