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Knowledge, attitude, and practices related to lead pollution among adolescents and caregivers of young children living near Used Lead Acid Battery (ULAB) recycling sites in Bangladesh: a cross-sectional study

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Abstract

Background Lead, a potent neurotoxin, causes irreversible damage to the nervous system, and low- and middle-income countries face huge health and economic productivity losses due to childhood lead exposure. In Bangladesh, informal Used Lead Acid Battery (ULAB) recycling sites are an important source of lead pollution. Little is known about lead awareness among communities exposed to ULAB recycling. Therefore, this study aims to assess knowledge, attitudes, and practices related to lead pollution among caregivers of young children and adolescents living adjacent to informal ULAB sites.

Methods A cross-sectional study was conducted among 732 mothers of young children and adolescents in 4 districts of Bangladesh (survey and observation). Simple and multiple linear regression was conducted to describe patterns and predictors of lead-related knowledge and practices.

Results 60% of respondents had heard the name 'lead' *("shisha")*. The mean knowledge score was low (19 out of 44). Residents of high-risk districts, male respondents, and those with more than 5 years of schooling were significantly more likely to have higher knowledge scores than others. In terms of attitude, 52% of respondents perceived lead to be risky for human health but 43% thought lead pollution was controllable. Observation of households for lead exposure revealed that 63% of children and adolescents play or pass by ULAB sites, 29% ate non-food items, 41% of households had visible paint chips on the walls, 59% households used polished turmeric and 15% used lead-soldered cans to store foods. Among protective practices, 70% reported cleaning floors, 84% consumed iron-rich foods, and 48% consumed calcium-rich foods.

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Conclusions The population had a high potential for lead exposure. Their knowledge about lead was limited, and risk perception was moderate. To reduce lead exposure and increase knowledge and awareness among the at-risk population, it is crucial to take measures such as mass awareness campaigns through media and schools. It is important to strengthen the implementation of existing policies, such as policies on leaded gasoline, paints, and lead-acid batteries, that can address the sources of lead exposure for the community.

Keywords Lead, ULAB, Knowledge, Attitude, Practice

Background

Lead, a potent neurotoxin [1], causes irreversible damage to the nervous system during early childhood development [2]. In addition to the nervous system, lead affects the circulatory, endocrine, renal, immune, and reproductive systems [3–6]. An analysis of pooled data from 1,333 young children from eight countries indicated that the difference in blood lead levels (BLLs) of 2.4–10 µg/dL and <2.4 µg/dL was associated with a decrease in four intelligence quotient (IQ) points [7]. Lead exposure harms all age groups and is particularly detrimental to children's health and development [8]. Lead competes with iron metabolism and interferes with heme synthesis resulting in anemia and malnutrition [9–13]. Effects of lead exposure vary based on the dose and duration [14]. The health impacts of lead exposure range from neurodevelopmental delays and neuropathy to death [15–17]. Low- and middle-income countries (LMICs) face an estimated US$977 billion in lifetime economic productivity loss yearly due to childhood lead exposure, and for Bangladesh, the estimate is US$16 billion [18].

In Bangladesh, researchers have reported various sources of lead exposure, such as lead-chromate in polished turmeric used as a spice, lead-soldered metal cans, geophagous materials (soil, clay, or ash), leaded paint, toys, tannery, dyeing, fertilizer, and Used Lead Acid Batteries (ULAB) recycling factories in the informal sector [19–23]. In Bangladesh, there is a rising demand for lead-acid batteries in transportation and other sectors. Currently, recycled lead meets 50% of the demand for lead in the country [24]. Much of the recycling of ULAB takes place in the informal sector with little regulation and oversight [23, 25–27]. According to the World Bank, there were 1,100 informal ULAB facilities in operation in Bangladesh in 2018 [28], and in 2020, a survey by PURE earth reported 270 ULAB sites [25]. Researchers have shown that the soil surrounding ULAB recycling sites is heavily contaminated with lead [19]. Lead contamination of soil and water results in the absorption of lead by the plants grown in the area and lead-contaminated food is one of the major pathways of chronic exposure [29].

In addition to identifying ULAB sites around Bangladesh [25], assessing the relationship between ULAB recycling activity and lead levels in human blood and soil samples [23], and describing the health consequences of soil remediation intervention [23], very few steps have been taken to reduce the impact of lead pollution at community- level. Some efforts have been made to inform the public through media about the lead contamination of turmeric and paint [30–35], and testing of household-level lead-awareness intervention package incorporated with an integrated intervention of child development [36]. However, little has been done so far to raise public awareness about lead contamination from ULAB recycling activities except for a few news articles and reports [25, 37–39]. In a previous study conducted in rural Bangladesh among caregivers of young children without any history of exposure from ULAB recycling activities, researchers reported that only 26% of the caregivers had heard about lead [36] but none of them knew its harmful effects on health. In the qualitative study conducted among the residents living close to ULAB recycling facilities, researchers reported a lack of understanding regarding lead among the population at risk [23]. However, quantitative evidence on knowledge, attitude, and practice regarding lead was not available in Bangladesh context. Therefore, the objective of the current study was to assess the knowledge, attitude, and practices among caregivers of children (aged 5–10 years old) and adolescents (10–19 years old) living near active or abandoned ULAB recycling sites. The insights from the study will be useful to raise awareness and support practices that can reduce lead exposure among high-risk populations.

Materials and methods

Study design and settings

We conducted a cross-sectional survey in four districts of Bangladesh. Based on the list of active and abandoned ULAB sites reported by Pure Earth, 2020 [25], we identified two districts with the highest concentration of ULAB (Tangail and Khulna) and two districts with the lowest concentration of ULAB sites (Sylhet and Patuakhali). The survey was conducted from January to March 2022.

Sampling and sample size

As we were interested in risk perception of lead among children and adolescent, we used a multi-stage sampling technique to identify representative sample of adolescent and caregivers of young children. A total sample of 732 allowed us to detect 26% prevalence of knowledge about lead among respondents with 80% power with 95% confidence [36]. From each high-risk district, we identified

3–4 sub-districts with a higher number of ULAB sites and purposively selected 15 clusters or unions (lowest rural administrative unit). We randomly selected 12 households from each cluster. For low-risk districts, one cluster was selected consisting of communities living close to active or abandoned ULAB site. Finally, 183 households were selected from each district. Total sample size for the study was 732.

Households with at least one child under 10 years or an adolescent aged 10–19 years old were identified. When there were two eligible participants of the same age group in a household, we selected the youngest one to enroll in our study. We maintained a 1:1 ratio of children and adolescents in each cluster during enrollment. Our respondents were the selected adolescents and the mothers/ caregivers of the children aged under 10 years. Respondents unwilling to participate in the survey were replaced with the next eligible one. In high-risk districts, 376 eligible households were contacted for enrolling 366 households (response rate 97.3%). In low-risk districts after approaching 392 eligible households 366 households were enrolled (response rate 93.4%).

Data collection tools and procedure

A semi-structured questionnaire was developed and pretested before data collection. The questionnaire included information on socio-demographic characteristics, and questions on knowledge, attitude and practices of households related to lead was administered face-to-face in Bangla. We used the Chicago Lead Knowledge Test (CLKT) scale [40], modified for the Bangladesh context to understand the respondent's knowledge. To modify the CLKT we identified questions that were not applicable to rural Bangladesh, such as those on leaded water pipes (when most of the households do not use piped water) were dropped from the tool. We added a few questions that are relevant in our context based on previous literature and expert consultation such as using polished turmeric. We translated the questionnaire into Bangla and pre-tested it outside the study area to ensure that the questions were understood. Based on field testing, we slightly modified 2 questions to ensure clarity before finalizing the questionnaire (Supplementary Table 1).

An observation checklist was developed for the enumerators to identify the possible sources of lead exposure at the households such as paint chips, ULAB remnants, lead-soldered cans, or metals.

The data collection team comprised of graduate-level research assistants led by a field supervisor. They attended a five-day training on the questionnaire followed by two days of field testing among non-study households. The training modalities included facilitated discussions regarding the contents of the questionnaire, training on the use of computer tablets for data collection, and role play.

We obtained a support letter from the Ministry of Health and Family Welfare (MoHFW) of Bangladesh and informed the local authorities before starting the survey in each district. Interviews and check-list completion in each household took about 30–40 min.

Data analysis

To assess the knowledge about lead among respondents, we used a modified Chicago Lead Knowledge Test (CLKT) scale consisting of 22 questions regarding knowledge on general information related to lead, exposure sources and pathways, preventive measures, and nutritional advice related to lead poisoning. For each correct and incorrect answer, scores of 2 and 1 were given respectively. If the respondents did not know the answer, they were given a score of 0. The total score ranged from 0 to 44.

The questionnaire had seven questions regarding lead-related attitude for which the responses were recorded in a three-point Likert scale. If the respondent did not know the answer, it was recorded as "don't know".

Descriptive statistics were computed for each variable: proportions for categorical variables and mean and standard deviation (SD) for numeric variables. To identify the factors associated with knowledge about lead, we performed bivariate and multivariate linear regression models and reported significance if p-value was less than 0.05. We used Stata Statistical Software: Release 13 and 16 (StataCorp LP, College Station, TX) for data analysis.

Ethical consideration

The research protocol was approved by the institutional review board of the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr, b) (protocol no. PR-21,127). Informed written consent was obtained from all respondents. Assent was taken for the adolescents aged 10–17 years in the presence of their guardians. We maintained the confidentiality and anonymity of the respondents and their responses throughout the data management, storage, analysis, and sharing processes. Our study prioritized the privacy and well-being of the participants throughout the process by minimizing harm and inconvenience to the participants during the interview process. During data management, we complied with the data security policies of icddr, b, and the government of Bangladesh during storing, and sharing the data and the results.

Results

Socio-demographic characteristics of the study samples

Among the 732 study respondents 366 were parents of children aged < 10 years and 366 were adolescents; 71%

were females; the majority of the respondents had more than five years of schooling; the mean household size was five; and the mean number of children in the households was two. The average monthly household expenditure of the respondents was US$ 211, and 27% of respondents lived within 200 m of an active or abandoned ULAB recycling site (Table 1).

Lead-related knowledge among study participants

Among our study participants, about 60% had heard the Bangla name for lead *("shisha")*. The proportion of those who heard about lead was highest in Tangail (79%), followed by Khulna (70%), Sylhet (60%), and Patuakhali (33%).

The average knowledge score for the study population was 19 (on a scale of 0–44). In the multivariate analysis, those living in high-risk districts had significantly higher knowledge scores compared to residents of low-risk districts; the male respondents had significantly higher knowledge score compared to females; and compared to the respondents with no formal schooling, those with schooling had significantly higher knowledge scores (Table 2).

Table 1 Socio-demographic characteristics of the study population

Characteristics	Total (*N* = 732) % (*n*)
Type of respondent	
Caregiver of young children	50 (366)
Adolescent	50 (366)
Gender	
Male	29 (212)
Female	71 (520)
Age of respondents (years) (mean ± SD)	23 ± 11
Education (in years)	
0	5.2 (38)
1–5	30 (220)
6–10	55 (401)
> 10	10 (73)
Occupation	
Homemaker	45 (327)
Student	41 (303)
Daily wage labor	2.9 (21)
Unskilled worker	2.5 (18)
Service holder	2.5 (18)
Business	2.2 (16)
Skilled worker	1.9 (14)
Others (farmer/ teacher/ van/ rickshaw puller)	2.0 (15)
Household size (mean ± SD)	5.1 ± 2.0
Mean number of children in household	2.2 ± 1.0
Socio-economic classification	
Poorest	20.2 (148)
2nd	20.2 (148)
3rd	19.7 (144)
4th	20.2 (148)
Wealthiest	19.7 (144)
Monthly expenditure (USD)[1] (mean ± SD)	211 ± 106
Household distance from ULAB	
0–200 m	27 (201)
> 200 m	73 (531)

[1]1USD ~ 84 BDT as of February-March 2022

Attitude about lead poisoning

Less than 50% of respondents answered "don't know" to the attitude questions indicating a lack of specific opinion about lead among the respondents. Regarding risk perception, 52% of the respondents thought that lead is risky for humans and the environment, and 52% of the respondents perceived that lead poses a moderate to high risk for the future generation. Almost one-third of the respondents thought that reduction of the risk of lead contamination was difficult, while 44% of respondents thought that lead pollution was controllable. Adolescents were significantly more likely to perceive that lead pollution was not controllable that caregivers of young children. Regarding healthcare providers' knowledge about lead pollution, only 25% of respondents believed that the healthcare providers had adequate or superior knowledge about lead (Table 3). Compared to adolescents, the caregivers of young children were significantly less likely to believe that health workers have adequate knowledge about lead.

Potential sources of household-level lead exposure and preventive practices

Based on our interview and spot-check, there were several potentially important sources of lead exposure in the sample. In terms of ULAB-related exposure, a large proportion (63%) of children and adolescents played or passed by ULAB sites, regularly ingested non-food items (29%) such as nails, dirt, pen, and pencil, and a small proportion (3%) had family members employed by ULAB business which could expose them to lead. Other potential sources of lead exposure observed included visible paint chips on the walls (41%), consumption of powdered and polished turmeric (59% and 10%), and use of lead soldered can for storing food (15%) (Fig. 1).

In terms of the diet of the study participants, 47% reported that they consumed foods from at least five food groups (out of ten), 84% had iron-rich foods, 48% had calcium-rich food, and only 8.1% consumed citrus food in the past 24 h. Regarding cleanliness of the household floor, 70% reported sweeping and mopping which could reduce exposure to lead (Fig. 2).

Table 2 Factors associated with lead-related knowledge score of the respondents

Independent variable	Unadjusted		Adjusted	
	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value
Respondent type				
Caregiver of children	Reference		Reference	
Adolescent	1.01 (-1.32, 3.33)	0.397	-1.99 (-4.50, 0.53)	0.122
Location				
Low-risk district	Reference		Reference	
High-risk district	9.71* (7.49, 11.9)	< 0.001	10.6* (8.40, 12.8)	< 0.001
Sex				
Female	Reference		Reference	
Male	4.83* (2.28, 7.37)	< 0.001	6.37* (3.70, 9.05)	< 0.001
Education (in years)				
0	Reference		Reference	
1–5	1.84 (-3.62, 7.30)	0.508	1.84 (-3.34, 7.03)	0.486
5–10	6.69* (1.42, 12.0)	0.013	6.52* (1.35, 11.7)	0.013
> 10	9.45* (3.24, 15.7)	0.003	11.7* (5.62, 17.8)	< 0.001
Distance from ULAB site (m)	0.0008 (-0.0008, 0.0023)	0.330	0.0005 (-0.001, 0.002)	0.496
Household socio-economic status				
Poorest	Reference		Reference	
2nd	1.06 (-2.59, 4.71)	0.568	0.21 (-3.21, 3.62)	0.906
3rd	1.62 (-2.05, 5.30)	0.387	-0.41 (-3.90, 3.08)	0.818
4th	2.85 (-0.80, 6.50)	0.125	-0.08 (-3.62, 3.45)	0.963
Wealthiest	5.02* (1.35, 8.70)	0.007	1.25 (-2.38, 4.88)	0.498

Note: In the table, the Reference means the comparison value for each categoric variable with which the other categories of that variable are compared

*$p < 0.05$

Discussion

We found that despite hearing about lead, adolescents, and mothers of young children living close to ULAB recycling sites were not adequately aware of lead pollution and its impact on health. A recent study on reducing the impact of lead exposure from ULAB recycling facilities [23] revealed a lack of understanding regarding the effects of lead among the exposed population. Researchers have studied the knowledge, attitude, and practice of adolescents, caregivers of young children, and health care providers in both developed and developing countries [40–45], but to the best of our knowledge, this is the first such study in Bangladesh using the modified Chicago Lead Knowledge Test tool. Given that ULAB recycling in the informal sector is an important source of lead exposure in Bangladesh [23], the assessment of knowledge, attitude, and practice related to lead pollution among caregivers of young children and adolescents will provide valuable insights into designing awareness raising campaigns among high-risk populations in the future in Bangladesh and other LMICs.

Knowledge

In our study, more than half of the respondents had heard of lead which was much higher than reported by a previous study in 2017 among mothers of young children in rural Bangladesh (60% vs. 26%) [36]. This difference of proportion might be due to the variation of the sample type and study site. The former study was conducted in Kishoreganj district among the pregnant women and caregivers of young children aged less than 12 months old and there were no ULAB sites in the study villages [36]. On the other hand, our study respondents were adolescents and caregivers of young children residing near ULAB recycling facilities. Despite hearing the name of the lead, the respondent's knowledge score was low (less than 50%), and the knowledge related to general information, exposure, prevention, and nutrition-related information was also low. As ULAB recycling businesses were informal and little has been done to date to raise awareness in the communities living adjacent to ULAB recycling sites, the lack of comprehensive knowledge among the community was expected. In terms of knowledge, males and those with higher education had significantly higher knowledge scores compared to others. Other researchers from Malaysia and China have reported a positive association between schooling and awareness of environmental pollution [46, 47]. The findings that male respondents had significantly higher knowledge scores than females could be due to their mobility [48], access to information and communication technology, education, and gender roles [49–51], which also indicates that campaigns need to include vulnerable women in health education about the risks and preventive measures.

Table 3 Perceived risk of lead poisoning among respondents

Variables	Total (*N* = 732) % (*n*)	Caregiver (*N* = 366) % (*n*)	Adolescent (*N* = 366) % (*n*)	*P*-value
How safe is lead for humans and the environment?				
Safe	6.0 (44)	5.2 (19)	6.8 (25)	0.781
Neither safe nor risky	0.96 (7)	1.1 (4)	0.82 (3)	
Risky	52 (381)	52 (190)	52 (191)	
Don't know	41 (300)	42 (153)	40 (147)	
How controllable do you think is lead pollution?				
Controllable	43 (316)	43 (156)	44 (160)	0.005*
Neither controllable nor uncontrollable	3.7 (27)	6.0 (22)	1.4 (5)	
Uncontrollable	9.8 (72)	8.2 (30)	12 (42)	
Don't know	43 (317)	43 (158)	43 (159)	
What is the level of risk posed by lead?				
Risky	56 (406)	54 (198)	57 (208)	0.793
Neither risky nor safe	0.55 (4)	0.55 (2)	0.55 (2)	
Safe	3.3 (24)	3.8 (14)	2.7 (10)	
Don't know	41 (298)	42 (152)	40 (146)	
What level of risk do lead pose for future generations?				
Risky	52 (381)	51 (187)	53 (194)	0.879
Neither risky nor safe	1.2 (9)	1.4 (5)	1.1 (4)	
Safe	5.2 (38)	5.7 (21)	4.6 (17)	
Don't know	42 (304)	42 (153)	41 (151)	
How easy is it to reduce the risk of lead contamination?				
Easy	20 (149)	18 (66)	23 (83)	0.474
Neither easy nor difficult	3.6 (26)	3.8 (14)	3.3 (12)	
Difficult	31 (227)	32 (116)	30 (111)	
Don't know	45 (330)	47 (170)	44 (160)	
What will be the trends in lead contamination levels in the future?				
Decreasing	17 (122)	15 (56)	18 (66)	0.589
Neither decreasing nor increasing	2.7 (20)	3.0 (11)	2.5 (9)	
Increasing	38 (281)	37 (137)	39 (144)	
Don't know	42 (309)	44 (162)	40 (147)	
How much do health professionals know about the risk of lead contamination for health?				
No/ minimal knowledge	17 (123)	20 (73)	14 (50)	0.005*
Basic knowledge	14 (99)	13 (48)	14 (51)	
Adequate/ superior knowledge	25 (179)	19 (71)	30 (108)	
Don't know	45 (41)	48 (27)	43 (14)	

*$p < 0.05$

Attitude

We found that respondents had a moderate-risk (52%) perception related to lead pollution despite a lack of adequate knowledge. The moderate-risk perception could be an artifact of the various public health campaigns about environmental pollutants such as arsenic, industrial waste, air pollution, and pesticides and their impact on health [52]. Despite high risk perception, respondents perceived that lead pollution was controllable, which indicated that they lacked an understanding of the complexity of lead pollution, its long-term effects, and mitigation options. Our findings indicate that there is an opportunity to take advantage of the moderate-risk perception to enhance community awareness and engage them in identifying polluting businesses such as ULAB recycling in the future. Engaging the community in limiting informal ULAB recycling activities would be helpful. In previous studies conducted in Bangladesh, researchers have reported that ULAB recycling facilities often operate below the radar of law enforcement authorities, and in the event of detection by the law enforcement authorities, they can easily relocate to a remote location which results in contamination of more areas and therefore, exposing more people to lead [23, 25, 38]. To limit the contamination, strategies should be taken to limit their relocation options. Also, researchers have shown that lead contamination of soil continues to expose people to lead even after ULAB facilities are shut down, and the

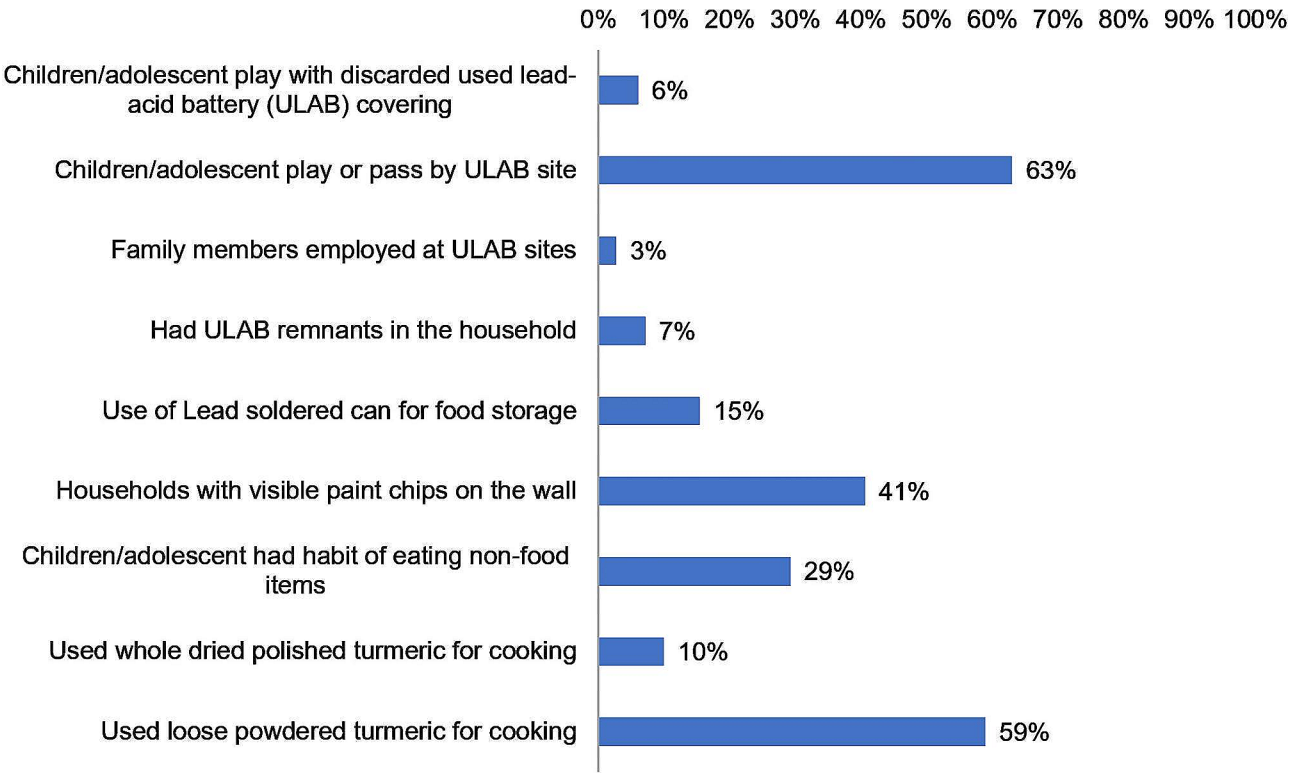

Fig. 1 Potential sources of lead exposure at the household level ($n = 732$)

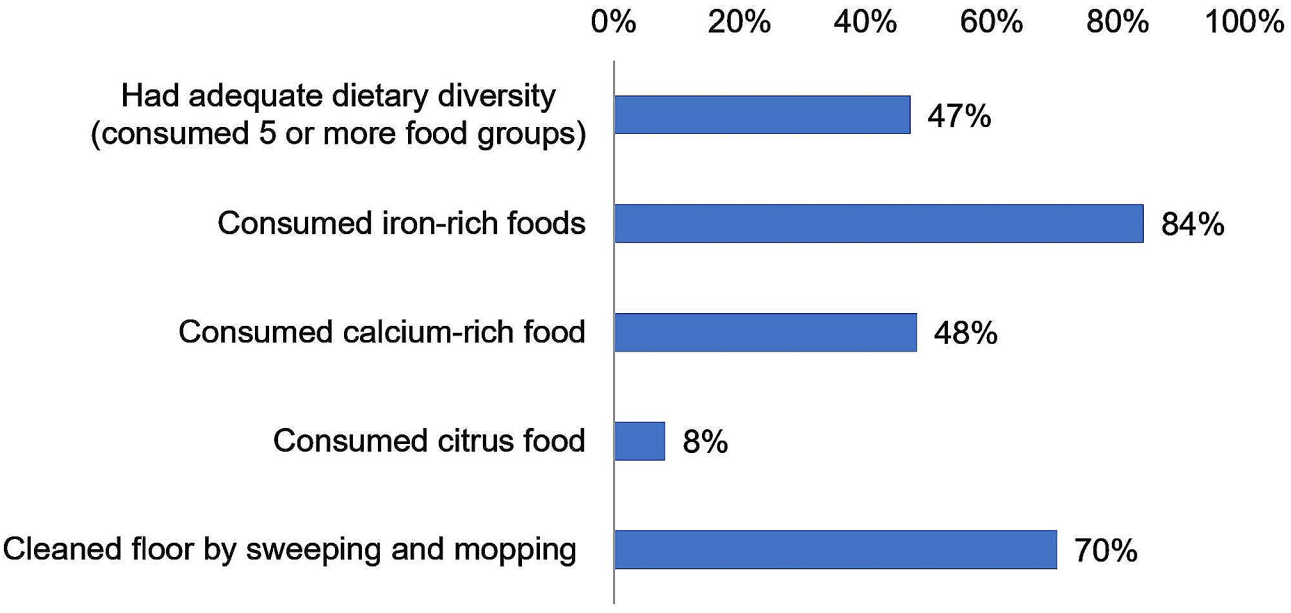

Fig. 2 Proportion (%) of respondents who practice behaviors that can reduce lead exposure or lead absorption ($n = 732$)

only way to prevent lead exposure from this source is to remediate the contaminated soil [25]. The soil remediation intervention is costly [23, 53]. Considering the economic status of Bangladesh, planning for continuous remediation activities in numerous sites will be an economic burden if frequent relocation of the informal ULAB factories is not prevented. Thus, it is important to design strategies to increase public awareness, engage the communities to identify informal ULAB facilities and engage the law enforcement authorities to stop such activities in the communities and prevent the relocation of the business.

Practice

In terms of practice, respondents commonly reported walking through and playing near ULAB sites. However, other possible sources of lead exposure, such as use of powdered or polished turmeric, paint chips, and lead soldered metal food containers, were also observed at the households. Previous studies have identified turmeric, paint, and food storage containers (made of tin and the cap is lead-soldered) and living adjacent to ULAB facilities as important sources of lead exposure in the communities around Bangladesh [19–23]. It is essential that any awareness-raising efforts whether for the general population or the high-risk population, include information about all important sources of potential lead exposure. In previous studies, researchers have shown that calcium-rich foods can inhibit lead absorption [54–56] while lead exposure can compete with iron absorption and result in iron-deficiency anemia. Further, iron deficiency can lead to higher absorption of lead [9, 10]. Hence, it is important that communities are given practical strategies related to food consumption and hygiene practices that can help protect them from lead exposure.

In Bangladesh, an estimated 35.5 million children have Blood Lead Levels >5 µg/dl, a cut off used to identify high levels of lead exposure [2]. Given the important effects of lead exposure on the growth and development of children, it is crucial to think about ways to prevent environmental contamination and reduce exposure to existing contamination. In the context of growing demand for lead-acid batteries, exponential expansion of informal ULAB recycling industries in LMICs [57], and inadequate enforcement of policies and resources allocated to deal with the informal sector, multisectoral actions must be taken to safeguard the future generation from lead exposure with active engagement of communities at high-risk. It is also important to raise general awareness of the population about lead pollution and its health impacts through health, education, and media channels so that youth, women, and community leaders are empowered to take preventive actions. To achieve the sustainable development goals 3, 6, and 12 [58], it is important that lead pollution receives urgent attention.

The strength of the study was that we used the modified Chicago Lead Knowledge Test tool to assess lead-related knowledge among the study population. This tool is used in many countries to assess knowledge of lead [40–43, 45]. However, there have been some concerns about the tool overestimating lead-related knowledge [59]. This study was conducted among population at high risk of lead exposure, thus the results are not generalizable for the general population which is a limitation of the study.

Conclusions

Our study indicated that most adolescents and mothers of young children living close to ULAB facilities lacked specific knowledge of lead exposure, exposure-related risks, and measures to prevent lead exposure. The respondents had a moderate-risk perception but thought that lead pollution was controllable. At individual and household-level, adolescents and young children were exposed to potential sources of lead both related and unrelated to ULAB recycling. To reduce the exposure to lead for communities living close to ULAB recycling facilities, it is important that people, especially those who are at high risk of lead exposure, are made aware of the different potential sources of lead pollution, the impact of exposure and practical strategies to protect themselves and their families. It is also crucial that awareness campaigns are designed to increase general awareness of lead pollution among the Bangladeshi population to increase their acceptance of and participation in the enforcement of existing laws regarding lead pollution. The policy makers and law enforcement authorities also need to strengthen their capacity to implement existing policies related to lead, such as policies related to lead-acid batteries, leaded paint, and leaded gasoline. In addition investments are needed for periodic identification of ULAB recycling sites and remediation of such toxic sites.

Abbreviations

BLLs	Blood lead levels
IQ	Intelligent quotient
LMICs	Low- and middle-income countries
µg/dL	Microgram per deciliter
MoHFW	Ministry of Health and Family Welfare
ULAB	Used lead acid battery

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

SR, MR, FK, FB, and JS contributed to developing the concept and study design. JS, FK AKS, and SSH helped with field implementation and data collection. JS, SR, FK, AKS, and SSH contributed to data management and data analysis. SR and FK guided manuscript writing and revision process. JS, TTN, and SSH prepared the draft manuscript. JS, TTN, SSH, FB, MR, PW, MV, DA, JF, FK, AKS, and SR contributed to critical review, revising and finalizing the manuscript. All authors read and approved the final manuscript.

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Data availability
The dataset we used for this manuscript is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by both the Research Review Committee (RRC) and Ethics Review Committee (ERC) of the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr, b). The approved protocol number was PR-21127. All the respondents provided informed written consent (in Bangla) before the interviews. The study procedure, risks and benefits, voluntary nature of participation, and right to withdraw from the study were explained during the consenting process. We maintained anonymity and confidentiality of the responses during data management and results sharing.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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