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PREVALENCE OF ELEVATED BLOOD LEAD LEVELS AND GENDER DIFFERENCES AMONG SCHOOL CHILDREN IN BANDA ACEH MUNICIPALITY, INDONESIA

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ABSTRACT

Lead toxicity is a major health problem in developing countries as lead exposure is widely scattered in the environment. Children are particularly vulnerable to the neurotoxicity of low-level, prolonged exposure to lead. Long-term effects of lead accumulation in children can damage them physically and mentally. We evaluated Blood Lead Levels (BLLs) among school children in Banda Aceh Municipality, Indonesia.

A cross-sectional study with randomly selected participants was conducted in 2 junior high schools to determine the prevalence of elevated BLLs and gender differences. Among 130 children, aged 12-15, 32 (24,6%) of them had elevated BLLs based on CDC reference ≥3,5 µg/dl with a mean of BLLs 3,01 ±1.14, and 27 out of 32 (84.4%) with elevated BLLs were males. Male students had 5.62 times higher risk (CI:2.00-15.81) with elevated BLLs compared to female students (p=< 0.001).

We concluded that the prevalence of elevated BLLs is high in both schools and there was a statistically significant difference in blood lead levels between male and female students. Other risk factors may affect the difference in blood lead levels among school children.

KEYWORDS: Blood Lead Levels, children, gender difference, Indonesia.

INTRODUCTION

Lead (Pb) contamination is still an environmental problem in many countries. Lead toxicity is a global concern due to its impact on various body functions. Case reports of lead poisoning have decreased dramatically in developed countries since the worldwide elimination of lead gas and the ban on the use of lead paint. However, the prevalence in developing countries is still quite high and remains a serious

threat to health worldwide [1–3]. Lead poisoning affects up to 800 million children worldwide or about one-third of all children [4]. Due to its physical material and chemical properties, lead has become one of the materials of household and daily products, such as pipes, furniture, paints, toys, batteries, tableware, cooking utensils, cosmetics, food ingredients or spices, tobacco, and pesticides, resulting in widespread lead contamination in the environment and children's lives [5–9]. Sociodemographic characteristics, including age, gender, education level, and socioeconomic status also influence the risk of exposure to lead [10–13].

The World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) state that there is no known acceptable blood lead level for children. The Blood Lead Reference Value (BLRV) by the CDC is used as a standard reference value to identify conditions that require health intervention. The reference value from the CDC has changed over the years. In 1991, the alert level for lead exposure was 10 µg/dl. Since 2012, the term BLRV has been used based on the child population, with a BLRV value of 5 µg/dl/. In October 2021, the CDC updated the blood lead reference value (BLRV) from 5 µg/dL to 3.5 µg/dl [14,15].

Even at low levels, exposure to lead at early age can lead to long-term effects such as neurological damage, cognitive function, low IQ, violent and strange behavior, and mental problems. Evidence about the health impacts of lead on gender has been documented in many literatures. Previous studies show that males are more likely than femaless to be exposed to heavy metals including lead [16], due to a combination of biological, behavioral, and environmental factors. There are physiological variations between boys and girls; changes in toxicokinetics could explain variations in neurotoxicity between genders; estrogen has been proposed as a neuronal regulator that protects against neurotoxicants [17]. Some researchers also suggest that boys may absorb more lead than girls. Traditional gender roles and societal expectations may also have impacts on their activities. Due to behavioral differences between boys and girls in Indonesia, boys are more likely to have contact with the risks in their surroundings than girls, which can increase their exposure to lead. For example, boys play more often outdoors leading them to contact metal or soil that contains lead or put objects in their mouths [18].

In 2021, a study of BLLs in several low-middle-income countries (LCMIs), estimated that about 71.208.000 children (aged 0–14 years) in Indonesia have exceeded 5 µg/dL and 10 µg/dL blood lead concentrations. This constitutes lead a severe threat to the well-being of children (19). Previous studies on BLLs in Indonesia were conducted in areas near used lead-acid battery (ULAB) recycling sites [13,20] or in large cities with industrial pollution [21,22].

Although huge industries or factories were not found in Banda Aceh Municipality, a northwestern tip city of Indonesia, previous studies of lead contamination reported that lead was found in sea, river, or plants [23–25]. To assess the BLLs problem among children in Banda Aceh Municipality and address the gender-specific factors, this study evaluates the prevalence of elevated BLLs in children and determines the variance in gender.

METHODS

A cross-sectional study was conducted in two public junior high schools (SMPN, Sekolah Menengah Pertama Negeri) in Banda Aceh Municipality, Aceh Province, Indonesia to determine the prevalence of

elevated blood lead levels in children. Participants were randomly selected in both schools. A total of 130 students were recruited in October and November 2022, which criteria included 12-15 years old, provision of parental consent, no known blood clotting disease, and the willingness to have blood drawn for the test. After the criteria were met, data identification was carried out and students' venous blood was drawn in the health room in one of the schools and the computer lab in another school. The blood samples were taken using the SST tube 6 ml (greiner) Austria, and stored at 2-8°c stable for 14 days. Then blood lead test was conducted by Prodia Laboratory, a private hospital, which has been certified in examining blood metal levels.

Statistical analysis was carried out using IBM® SPSS®. Descriptive data analysis was displayed in percentages. Mann-Whitney test was conducted to see the mean difference between gender and BLLs elevation due to not normally distributed data. Pearson chi-square was used to analyze categorical data.

RESULT

Among 130 students who participated in this study, 75 (57.7%) were male and 55 (42.3%) were female (Table 1). By age category, they consisted of 2.3% of 12 years old (n=3), 77.7% of 13 years old (n=101), 18.5% of 14 years old (n=24), and 1,5% of 15 years old (n=2). The mean of BLLs was 3.01 µg/dl (range 1.10 -7.60 µg/dl, SD=1.14). Based on BLLs reference by CDC 2021, 24.6% (n=32) students had elevated BLLs ≥3,5 µg/dl and 84.4% (n=27) of them were male.

Mann-Whitney test showed a difference in the mean BLLs values in the male and female groups. The female group had a mean value of 2.52 µg/dl (range 1.10 - 4.70, SD= .756), which was lower than the male group of 3.37 µg/dl (1.50 - 7.60, SD= 1.247). The rank of blood level with gender difference is displayed in Figure 1. This research categorized the blood levels as normal and elevated. Then conducted analysis based on gender differences using a chi-square test. We found that males were 5.62 times (95% CI 2.00–15.81) more likely to have elevated blood levels than females. Thus, the result was highly significant (p=< 0.001) *(Table 1)*.

Table 1. (*Cross-tabulation of gender and blood lead level.)*

Gender	Normal BLLs		Elevated BLLs		Total		P value (χ^2) [a]	OR (95% CI)
	n	%	n	%	n	%		
Male	48	49	28	84.4	75	57.7	< 0.001	5.62 (2.00 – 15.81)
Female	50	51	5	15.6	55	42.3		

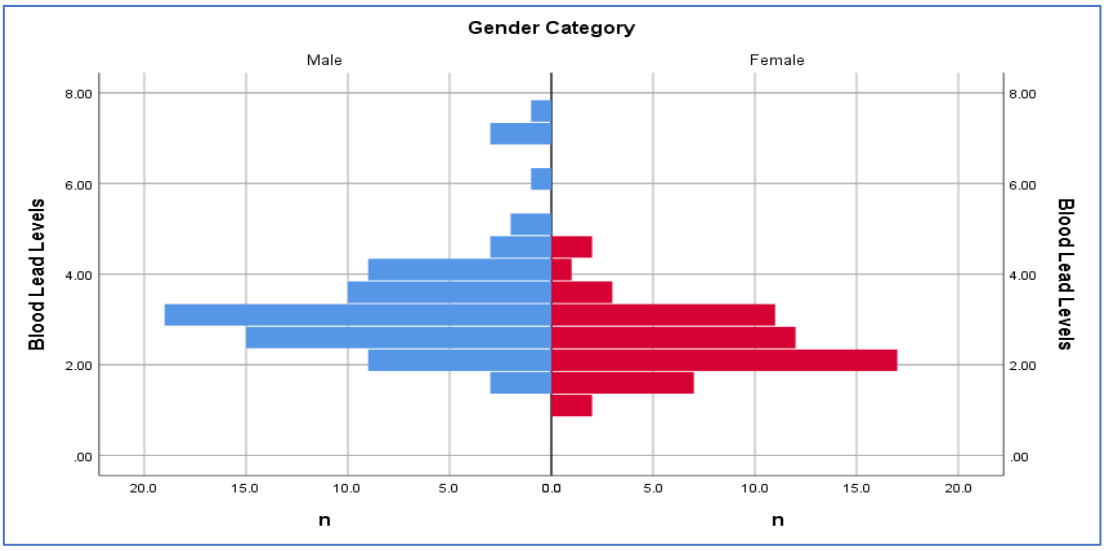

Figure 2 *(The different distribution of blood lead levels ranks by gender.)*

DISCUSSION

Lead exposure remains an essential health problem in LCMIs such as Indonesia. A recent systematic review, in which 3 studies with a sample of 387 children from Indonesia were included in the review, showed a pooled mean of BLLs of 5.2 µg/dL with SD=3 [19], which is higher than the mean in our study (3.01 µg/dL with SD=1.14). Other studies in ULAB recycling sites in Jakarta and Bogor also show higher mean of BLLs (17,03 µg/dL, and 4.69 µg/dL, respectively) [13,20]. In addition, the mean of BLLs of Jakarta and Serpong school children were 8.6 µg/dL and 6.4 µg/dL [11,21]. This study also found that 24.6 % of students had elevated BLLs, lower than previous studies in other cities in Indonesia. However, the studies in other cities of Indonesia took samples from the communities affected by manufacturing pollution or battery recycling business. Meanwhile, this study took samples from the regular communities (students) living in the city center of Banda Aceh municipality, where there is no report of industrial pollution.

The calculation of this study was based on the prevalence result and population of 72,162 children aged 0-14 years in Banda Aceh Municipality [26]. This study estimated that about 17,752 children in Banda Aceh Municipality are likely to be at risk of elevated BLLs. With a prevalence of nearly 25% and without definite exposure sources, the finding of this study should be of concern to the government, specifically in prevention and identifying potential sources of lead exposure in the municipality.

Lead exposure and its effects are influenced by gender. However, various determinants trigger differences in BLLs values based on gender. The result of this study shows that male students had a 5.62 times higher risk of BLLs compared to female students. The findings confirm previous research showing that the male has higher BLLs than the female [6,11–13,27]. It is still unclear to this study why the boys are more likely to have a higher risk of lead exposure in Banda Aceh Municipality. One of the assumptions that might explain this is that from an early age, girls and boys interact with their environment in distinct ways (18).

In Banda Aceh Municipality, local tradition has different expectations of gender roles between boys and girls. Boys are more likely, as they are encouraged, to play outdoors which puts them at a higher risk of interacting with risky environments, such as waste areas, scrapyards, old buildings, and factories. Therefore, they are more exposed to air pollution and other environmental pollution than girls, who are less expected to play outside of the house. This traditional expectation constructs behavioral differences between boys and girls, which might also contribute to the higher risk of contact with lead. For example, boys are more likely to play with objects containing lead. This may cause great ingestion of lead-containing dust or particles into the mouth or skin since they tend to have poorer hygiene.

Physiological aspects such as differences in hormones and organ functions between males and females affect the accumulation of lead in the body. After absorption, lead is initially retrieved and distributed by blood. About 90% of blood lead is found in red cell blood (RBC). Higher RBC levels of lead in males may bring them to a higher risk of lead binding. In contrast, the role of female's hormones affects lead absorption which results in a lower BLLs value in their circulation. However, the accumulation of lead in the bones can escape and increase BLL levels when they grow due to low estrogen hormones such as during periods, breastfeeding, or menopause (8,28–30). Therefore, the risk of lead exposure in males is more susceptible at an early age than in females. The study was conducted in a city with no point sources of industrial contamination. Therefore, it is probable that the main source of lead exposure in Banda Aceh Municipality is the pollution of vehicles, drinking water, and food.

CONCLUSION

The BLL value was significantly different between genders which may be affected by the duration of exposure and biological factors in the human body. Thus, further study is essential to determine gender-related risk and analyze sociodemographic factors and sources of exposure. Identification of high-risk groups is one of the primary intervention efforts to prevent the lasting effects of lead exposure. In the Banda Aceh Municapility context where nearly 25% of sampled children have detectable elevated BLLs, urgent intervention action is needed, which includes screening children on a regular basis, testing and identifying homes and environments with lead contamination, and running awareness programs to inform parents and teachers about the risk of lead exposure.

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