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ORIGINAL ARTICLE

Lead exposure and stunting incidents in children aged 3—5 years in Pontianak City, West Kalimantan, Indonesia

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Summary The morphology of West Kalimantan with peatlands and tropical climate conditions makes this area vulnerable to the danger of land fires. Therefore, the pollution resulting from land fires and motorized vehicle transportation reduces air and rainwater quality. The utilization of rainwater as a source of drinking water for the people of Pontianak can affect the health of children under five. The prevalence of stunting in toddlers is high in Pontianak, but research on the effect of exposure to heavy metals leading to stunting is still lacking. This study aims to evaluate the relationship between the lead in drinking water and Urinary Lead on the incidence of stunting in toddlers. The research method used a case-control approach with a total sample of 60 children aged 3—5 years. Data collection was carried out from August to November 2021. Overall, the results showed that there was a significant difference in urine Pb levels in affected toddlers comparing to healthy ones ($P \leq 0.001$), while Pb levels in drinking water sources did not differ significantly on the incidence of stunting in toddlers ($P = 0.068$). To conclude, there were differences in urine Pb content, but there was no significant link between Pb levels in drinking water sources and the incidence of stunting in children.

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Introduction

Stunting is a serious health problem in children, estimated at 156 million children worldwide [1]. Low- and middle-income countries have a higher risk (12-fold higher prevalence of 0.7%) than high-income countries [2]. Stunting cases of children aged 5 years in 2015 globally experienced an increase compared to 1990, which was 98.5 million children, while in East Asia and the Pacific and South Asia, stunting prevalence decreased by 24.8% and 25%, respectively. The distribution of children under the age of 5 years is not disproportionately distributed; the decrease in prevalence does not result in a reduction in the number of stunted children globally [1]. Data on the prevalence of stunting under five collected by the World Health Organization (WHO) shows that Indonesia has the top three stunting prevalence in the Southeast Asian region. The average prevalence of stunting under five in Indonesia in 2005—2017 was 36.4% (Stunting 2018). The prevalence of stunting in West Kalimantan is still high in 2019; it was 27.30%, with the most extensive prevalence distribution in Kapuas Hulu district (35.26%) [3].

The determinants of stunting are generally caused by poor nutritional intake of children associated with diet and infection [4,5]. One of the risk factors for stunting that has been carried out in the research shows that environmental sanitation results, including the availability of latrines and the quality of drinking water, have a higher risk [6,7]. Research has begun to study exposure to toxic environments, including lead [8—11]. Lead exposure is associated with various nutritional deficits and ultimately impairs neurodevelopment in children [12—14]. Children exposed to food contamination and are subjected to environmental contaminants, such as metals, are particularly vulnerable to the absorption of food nutrients. One standard indicator of a nutritional deficit is stunted growth, which occurs when a child's height (or length) for a given age is below the 5th percentile [7].

The environmental condition of West Kalimantan, which is mostly peatland and located in the equator, is prone to land fires. Industrial activities and the use of fossil fuels for motor vehicles continue to increase. Land fires occur almost every dry season, which results in high levels of air pollution and affects the quality of rainwater. Several sources cause potential factors for lead pollution in West Kalimantan, including air pollution, which decreases the quality of rainwater used as a source of drinking water for the community [15,16]. The release of lead into environment will eventually enter the food chain and impact human health.

Toddlers have a higher risk of absorbing heavy metals such as Pb than adults [17]. The pathway for Lead exposure in toddlers can be through breast milk, food and water consumed, and the habit of putting hands in the mouth. External Pb exposure scenarios are always tricky to evaluate; thus, internal dose measurement can achieve the assessment of Pb exposure. Generally, the internal Pb dose is often measured using a blood sample to reflect further Pb absorption. Therefore, it is not easy to obtain blood samples of young children, especially infants, so urine samples are an alternative that needs to be evaluated for Pb exposure [17].

This study aimed to analyze the role of Lead exposure in drinking water sources in influencing the incidence of stunting in children aged 3-5 years in Pontianak City. In this analysis, the researchers hypothesized that stunting is affected by exposure to Lead from drinking water and the environment. Therefore, in this study, we focused on Lead in drinking water and in urine as the impact of environmental pollution causing stunting in toddlers. Targeted interventions to ameliorate chronic malnutrition would effectively reduce the detrimental effects of Pb exposure from drinking water.

Materials and methods

Study design and population

The research was conducted in the city of Pontianak with two subdistricts that became the object of research, namely, Siantan Hulu and Siantan Hilir subdistricts. The study used case-control, namely, compared the case and control groups and then retrospectively examined the risk factors that might explain the cases and controls. Stunting toddlers as cases and controls was obtained based on the Pontianak City Health Office data in 2021. The data obtained from the City Health Office was adjusted to the data in the work area of the Puskesmas, which was the object of research. Stunting toddlers cases are recorded at the Pontianak City Health Office and are physiologically confirmed. Controls are toddlers aged 3-5 years who have been physiologically approved as non-stunting in the work area of the Pontianak City Health Office. The inclusion criteria of the respondents were toddlers aged 3-5 years, the stunting indicator uses the calculation of height based on age, namely the cut off z score, where stunting has a z score of $\leq$-2 SD and normal > -2 SD, from birth lived in the city of Pontianak, and their parents were willing to be involved in this study by signing the consent form. Consent forms were obtained from all parents of children in the survey. Exclusion criteria for participants were children under five who were not born in the city of Pontianak; their home address had changed or died on the study date.

Sample and data collection

The number of samples in this study was 60 toddlers consisting of 30 cases and 30 controls. Trained interviewers collected data and samples from well water and urine. Respondents were interviewed between August 2021 and November 2021. Pb examination of drinking water and urine was carried out at the Laboratory of Poltekes Kemenkes Pontianak.

Estimated intake of nutritional needs

Food record for 1 $\times$ 24 hours was used as information regarding the nutritional intake of toddlers. Parents of toddlers were asked to recall the food given to their children. The amount of food consumed using household units of measure is converted into units of weight (grams)[18]. The collected data were processed using Nutrisurvey modified by 2007 software (EBISpro, Germany). The results of the 2007 Nutrisurvey Analysis were compared with the intake of macronutrients (Calories, Carbohydrates, and protein) and compared with the nutritional adequacy rate for children under five issued by the Ministry of Health of the Republic of Indonesia [19].

Technique for Water and urine sampling

A clean water sample is put into a 2.5 ml polyurethane sample bottle. To prevent contamination of the sample bottles in a clean condition and during the shipment of samples tightly closed. Delivery of samples to the laboratory using a Cool Box containing ice. Urine samples were taken in the morning after the toddler woke up from sleep. Sterile urine bag collectors are glued using adhesive after the area around the baby's vital organs is cleaned to reduce the risk of being contaminated with bacteria on the skin.

Lead analysis in water and urine samples

Method Laboratory analysis for lead in clean water and urine using Atomic Absorption Spectrophotometer (AAS). The test was carried out by adding a standard reference solution (Pb 10 ppm) into the sample to be examined before being destroyed with the sample in duplicate. Then a blank test was performed (without adding a standard solution). Each sample was then digested using the wet digestion method using HNO_3 H_2SO_4 and measured using AAS at a wavelength of 283.3 nm [20].

Statistical analysis

The effect of Lead levels in drinking water and urine sources on the incidence of stunting in toddlers aged 3-5 years using the Mann-Whitney Test and 95% confidence. The analysis results were used to perform a multivariate analysis using logistic regression to obtain the ideal model for the incidence of stunting. Step-by-step logistic regression methods were used to determine the most suitable model to analyze the relationship between Pb in urine and stunting.

Results

Population characteristics

A summary of the characteristics of the study population is presented in Table 1. In general, the population is primarily

Table 1 Demographics of the study population.

Study Population Characteristics	All *n* (%)	Stunted *n* (%) or mean ± SD	Not Stunted *n* (%) or mean ± SD	*P*-value
Observations (*n*)	60	30	30	
Child sex				
Male	12 (20%)	10 (33.3%)	2 (6.7%)	0.024
Female	48 (80%)	20 (66.7%)	28 (93.3%)	
Mother's education				
Primary school or less	11 (18.3%)	7 (23.3%)	4 (13.3%)	0.505
Secondary school or greater	49 (81.7%)	23 (76.7%)	26 (86.7%)	
history of illness				
Yes	8 (13.3%)	3 (10%)	5 (16.7%)	0.706
No	52 (86.7%)	27 (90%)	25 (83.3%)	
Parents' Income				
<City Minimum Wage	8 (13.3%)	5 (16.7%)	3 (10%)	0.706
≥City Minimum Wage	52 (86.7%)	25(83.3%)	27(90%)	
Parity				
1—3	54 (90%)	24(80%)	30(100%)	0.024
4—6	6(10%)	6 (20%)	0 (0%)	
Nutritional Intake				
Deficit	11 (18.3%)	6 (20%)	5 (16.7%)	1.000
Not Deficit	49 (81.7%)	24 (80%)	25(83.3%)	
Drinking Water Source				
Rainwater	49(81.7%)	25 (83.3%)	24 (80%)	1.000
Refill Water	11(18.3%)	5(16.7%)	6(20%)	
Smoking at home				
Yes	51(85%)	25 (83.3%)	26 (86.7%)	0.551
No	9(15%)	5 (16.7%)	4 (13.3%)	
Lead in water (mg/L)				
mean ± SD	—	0.0669 ± 0.0784	0.0350 ± 0.04911	
≥0.01	31 (51.7%)	19 (63.3%)	12 (40%)	0.071
<0.01	29 (48.3%)	11 (36.7%)	18 (60%)	

Reported *P*-values for the Chi^2 test for dichotomous variables (Lead in Water, gender, mother's education, and history of illness, Parent's income, parity, nutritional intake, source of drinking water,smoking at home.

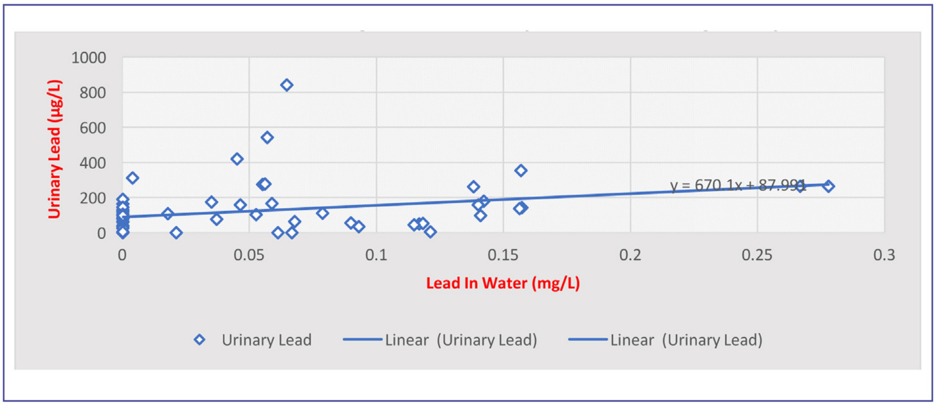

Figure 1. Relationship between drinking water lead and urinary lead in toddlers aged 3—5 years. ([a] Spearmen's rho, α=95%,$P = 0.019$; R = 0.302, R Square = 0.092).

Table 2 Differences lead levels in drinking water sources and urinary lead on stunting in toddlers.

Group	Lead in Drinking Water (mg/L)		*P*-Value[a]
	Min ± Max	Median ± SD	
Stunted	0.0001 ± 0.2779	0.0496 ± 0.0784	0.068
Not Stunted	0.0001 ± 0.1410	0.0001 ± 0.0491	
	Urinary Lead (µg/L)		
Stunted	60.40 ± 842.0	161.25 ± 161.115	≤ 0.001[b]
Not Stunted	0.1 ± 0.98.60	15.40 ± 33.197	

[a] Mann—Whitney Test (α = 5%).
[b] Significant at $P \leq 0.05$.

female (80%), and there is a significant relationship between sexes and the incidence of stunting in children aged 3-5 years ($P = 0.024$). The education of parents of toddlers is mostly a secondary school or more outstanding (81.7%). Most of the children under five had never been hospitalized (86.7%). Baita's parents' income is mostly more than City Minimum Wage (86.7%). Most of the toddlers who became respondents were in parity 1—3 (90%) and had a significant relationship between equality and the incidence of stunting in toddlers ($P = 0.024$). The nutritional intake of toddlers is mostly fulfilled (81.7%), with the source of drinking water used mostly rainwater (81.7%). Most family members smoking at home (85%).

Relationship between Lead in drinking water and urinary lead in toddlers aged 3-5 years

Fig. 1 shows a trend between Lead levels in drinking water and urinary lead in toddlers' urine. Statistical analysis showed a correlation between lead in drinking water and urinary lead ($P = 0.019$) but had a weak relationship (correlation coefficient= 0.302). The relationship between Pb in drinking water and Pb in urine has a positive relationship, where the higher the Pb detected in drinking water, the higher the Pb in urine. The statistical test results showed that lead in drinking water had a 9.2% contribution effect on urinary lead, while 91.8% was influenced by other lead exposure, which was not carried out in this study.

Relationship of lead in water levels and urinary lead with stunting in toddlers

Table 2 shows Pb levels in drinking water sources in the stunting case group tended to be higher than the Pb levels in drinking water in the control group (not stunting). The average Lead content of the water used as a source of drinking water for the case group (stunting) was 0.06669 mg/L. Statistically, there was no significant difference in Lead levels in drinking water in the case and control groups ($P = 0.068$). Urinary lead levels in the stunting case group tend to be higher than urinary lead levels in the control group (not stunting). The median urinary lead level in the case group (stunting) was 161.25 (µg/L). Statistically, there was a significant difference in urine Pb levels in the case and control groups ($P \leq 0.001$).

Discussion

This study analyzed the relationship between lead exposure in children under five and the incidence of stunting. In this study, samples were taken to describe Pb exposure using a toddler urine biomarker. The research subjects were stunted and non-stunted toddlers. Urine biomarkers are an alternative in describing Pb exposure in toddlers and blood biomarkers that can tell Pb exposure [21,22]. There is a difference between Pb exposure in urine and the incidence of stunting in toddlers in Pontianak, Kalimantan. Metal exposure in children under five in this study was associated with Pb testing for drinking water sources. Pb exposure in drinking water did not show a significant difference, but there was a tendency for Pb in drinking water to be higher in the case (stunting) group than in the control group.

The source of drinking water for the community generally uses rainwater. Rainwater used by the community as a source of drinking water contains Pb. The Pb content in rainwater taken from the reservoir showed varying levels. The Pb content in drinking water from rain can be affected by the level of pollution in Pontianak City and the way people collect rainwater through the roofs of houses made of [15,16]. The content of drinking water in the community did not show a statistically significant relationship with the levels of Pb detected in the urine of toddlers. Pb levels in infants and water consumption factors can also be triggered by exposure through contaminated food and air.

The relationship between Pb Urine and stunting in toddlers in Pontianak is in line with the research conducted by Kim, Jin Hee et al. [17]. The results showed that the levels of Pb and Hg in Urine toddlers are exposed to above the standards of human biomonitoring I and II, regardless of the levels in other biological samples such as blood [21]. Exposure to Pb in urine can indicate tissue or other body organs being exposed to Pb. Pb in urine is the result of body excretion due to lead exposure. Lead exposure accumulates in bone tissue, kidneys, and other organs[23].

Effect of lead can cause a decrease in IQ in children where the relationship between blood lead concentration and cognitive scores at the age of 2—3 years with an increase of 1 μg/dL of lead concentration in umbilical cord blood in children with stunting decreased cognitive scores 2.1 units ($\beta = 2.10$, $SE = 0.71$, $P = 0.003$) [24]. The results of another study conducted by Kponee-Shovein, Kalé Z., et al. (2020) using a neural biomarker in the form of Pre-Pulse Inhibition (PPI) showed an increase of one standard deviation for the parametric g-formula (10.0 g/g) on prenatal lead significantly reduced PPI by about 19.0% (95% CI: 5.4%, 34.3%) [14].

Research and interventions on stunting focus on poverty, nutrition, and development. These determinants are assumed to be the most decisive factors in triggering stunting in toddlers. Still, the adverse effects of exposure to heavy metals and air pollution are increasingly becoming challenges in the future as essential points for intervention. This factor will become increasingly important because the number of chemicals in the environment will continue to increase along with changes in the environment and pollution levels [10,25].

Conclusion

There is a difference in the levels of urinary lead between stunted and non-stunted toddlers. Still, the levels of lead in the water consumed do not show a significant difference between stunted and non-stunted toddlers. Therefore, it is necessary to do further research to analyze the causes of high urinary lead in toddlers other than drinking water sources in the form of air pollution and contaminated food, which have implications for stunting.

Ethical statement

The study protocol was reviewed by the Health Education Ethics committee and given ethical clearance. Official permission was obtained from the ethics committee of Faculty of Public Health, Universitas Diponegoro with registration number: 371/1/EA/KEPK-FKM/2021. Written consent was obtained from all parents of children under five and the Pontianak City Health Office

Disclosure of interest

The authors declare that they have no competing interest.

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