Risk Factors for Undernutrition and Diarrhea Prevalence in an Urban Slum in Indonesia: Focus on Water, Sanitation, and Hygiene

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Abstract. Unsafe drinking water and poor sanitation and hygiene lead to deterioration of the child health condition in low- and middle-income countries. This study aimed to evaluate the nutritional and health status of children living in an urban slum and to clarify the factors contributing to undernutrition and diarrhea prevalence by focusing on water, sanitation, and hygiene from three viewpoints: household environments, child personal hygiene practices, and knowledge and awareness. The study was conducted at a preschool and two elementary schools in the densely populated area of Bandung, Indonesia. Participants were 228 pairs of children and their caretakers. The survey involved 1) anthropometric measurements (height and weight), 2) handwashing observation using a checklist, and 3) questionnaires. On multivariate logistic regression analysis, not using a towel for handwashing practices (adjusted odds ratio [AOR] = 2.37; 95% confidence interval [CI] = 1.13–4.96) was significantly associated with an increased risk of stunting. Regarding household environments, children from households using tap water as drinking water were significantly associated with an increased risk of stunting and thinness compared with households using tank water (AOR = 2.26; 95% CI = 1.03–4.93; and AOR = 2.88; 95% CI = 1.13–7.35, respectively). Moreover, children from households using open containers for water storage were significantly associated with an increased risk of diarrhea (AOR = 5.01; 95% CI = 1.08–23.15). Therefore, drinking water management at home and proper personal hygiene practices of children are important for maintaining and promoting child health in urban Indonesian slums.

INTRODUCTION

Based on a report by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF), 89% of the world's population used at least basic drinking water services but only 68% used at least basic sanitation services in 2015.¹ The United Nations Sustainable Development Goals aim to achieve universal and equitable access to safe and affordable drinking water, and access to adequate and equitable sanitation and hygiene for all by 2030 (Targets 6.1 and 6.2).² Contaminated drinking water, and poor sanitation and hygiene lead to deterioration of the child health condition, indirectly causing undernutrition.³ According to recent estimates, access to improved water, sanitation and hygiene (WASH) could prevent 58% of diarrheal deaths among children under the age of 5 worldwide per year.³ These findings emphasize the importance of safe water, sanitary condition, and proper hygiene for child health.

Numerous studies have investigated the relationship between child health and WASH in low- and middle-income countries. Previous studies found that household sanitation and the caretaker's personal hygiene practices are strong predictors of child stunting⁴ and that a high-quality toilet has a protective effect for risk of diarrhea and stunting in children.⁵ Urban slums in low- and middle-income countries possess several challenges, such as dense population, lack of durable housing, insufficient living area, insecure tenure, and poor access to improved water and sanitation⁶ and these challenges might affect child health. Moreover, a previous study revealed that children in slums face higher health risks than children in urban areas who do not live in slums, but the risk is lower than children living in rural areas.⁷ In Indonesia, untreated drinking water and unimproved sanitation were strong

predictors of child stunting,⁸ and use of piped water reduces the risk of diarrhea in children.⁹ However, the relationship between WASH and child health in urban slums of Indonesia remains unclear.

Assessing handwashing behavior requires attention. A previous study suggested that self-reported handwashing behavior overestimates actual behavior.¹⁰ Therefore, a comprehensive evaluation of handwashing behavior requires using questionnaires, demonstration, and observation at the same time. However, such approaches are time and labor consuming and might thus be difficult to apply to a large sample. This study aimed to evaluate the nutritional status of children living in an urban slum. In addition, researchers conducted direct observations and a questionnaire survey to clarify the factors contributing to undernutrition and diarrhea prevalence by focusing on WASH from three viewpoints: household environments, child personal hygiene practices, and knowledge and awareness.

METHODS

Study area and participants. This cross-sectional study was conducted in the densely populated area (around 20,000 people/km²) of Bandung, West Java Province, Indonesia, from August to September 2017. Data were collected in cooperation with a preschool facility, *pendidikan anak usia dini* (PAUD), and two elementary schools located in the area. All children and their caretakers in PAUD, and children of grades 2, 4, and 6 and their caretakers in the elementary schools were enrolled. After explaining the purpose and contents of the survey, 228 pairs of children and caretakers participated. Children who were unable to obtain consent from their caretakers and/or were absent during the investigation period were excluded.

Anthropometric measurements. Height was measured to the nearest 0.1 cm using a stadiometer (Seca 213; Seca, Hamburg, Germany) and body weight to the nearest 0.1 kg

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using a digital weight scale (BC-754-WH; Tanita, Tokyo, Japan). Body mass index (BMI; in kg/m²) was calculated from the height and weight measurements. The ages of the children were calculated by software (WHO AnthroPlus version 1.0.3¹¹; WHO, Geneva, Switzerland) using date of birth (reported by caretakers) and research date. Height-for-age z-scores (HAZ) and BMI-for-age z-scores (BMIAZ) were calculated from the anthropometric measurements using an international reference^{12,13} (WHO AnthroPlus version 1.0.3 software). Children with HAZ < -2 were categorized as stunted, and those with BMIAZ < -2 and > +2 as thin and obese, respectively.^{11,13,14}

Handwashing skill check. To evaluate the handwashing skills of children, a checklist was modified based on WHO handwashing procedures.¹⁵ The following 10 steps were included: 1) wet hands with water; 2) apply enough soap to cover all hand surfaces; 3) rub hands palm to palm; 4) rub right palm over left dorsum with interlaced fingers and vice versa; 5) rub palm to palm with fingers interlaced; 6) rub backs of fingers to opposing palms with fingers interlaced; 7) rub rotationally left thumb clasped in right palm and vice versa; 8) rub rotationally backward and forward with clasped fingers of right hand in left palm and vice versa; 9) rinse hands with water; and 10) dry hands thoroughly with a single-use towel. Children also received the following instructions: to use freely any materials such as water, soap, and towel that were prepared, and to do what is usually practiced at home before demonstrating their handwashing practices. A single researcher (Y. O.) noted every behavior according to the steps.

Questionnaires. Structured questionnaires were developed according to preliminary research and under discussion with local people to make it suitable to local context and administered to caretakers and elementary school children. Questions for caretakers included the following: 1) basic demographics, including age, educational background, occupation, household monthly income, and household environment (drinking water source, toilet type, sewerage); 2) WASH knowledge and awareness, and handwashing behaviors (see Supplemental File 1); and 3) reported period prevalence of the child's diarrhea and respiratory symptoms during the past 2 weeks.

Water, sanitation, and hygiene knowledge and awareness scores were calculated from the correct answers in WASH knowledge and awareness section. Regarding handwashing behaviors, participants were asked what they usually do to clean their hands at the occasions modified with reference to a recommendation by the Centers for Disease Control and Prevention.¹⁶ Handwashing behavior was categorized into always handwashing with soap or not according to their answer. Diarrhea was defined as the case of three or more loose or liquid stools per day.¹⁷ For elementary school children, a questionnaire regarding WASH knowledge and awareness (only questions 1–8) and handwashing behaviors (only six occasions) was selected and prepared to suit their age by using words that are easily understood.

Statistical analysis. Bivariate analysis was performed between stunting, thinness, diarrhea prevalence, and each individual variable (i.e. household, caretaker, and child characteristics). The independent variables were chosen from covariate variables: 1) those that had significant differences in stunting, thinness, and diarrhea prevalence on bivariate analysis; 2) children's health status and relevance pointed out

in previous studies; and 3) WASH items of interest in this study. Stepwise forward selection methods were then performed on these variables. Multivariate logistic regression analysis was performed using stunting, thinness, and diarrhea prevalence as dependent variables. A *P* value of < 0.05 was considered statistically significant. JMP 13.1.0 software (SAS Institute Japan, Tokyo, Japan) was used for all statistical analyses.

Ethical considerations. This study was approved by the ethical review committee of the Faculty of Health Sciences, Hokkaido University (No. 17-13). We explained the purpose and contents of the study to all participants and obtained written consent from all children (except PAUD children) and all caretakers.

RESULTS

Characteristics of participants. Household and caretaker characteristics are shown in Table 1. Regarding the caretakers' educational background, more than half of them had above-high school graduation. When dividing household income into low (< 2,000,000 rupiah or US\$160), middle (2,000,000 to < 4,000,000 rupiah or US\$160 to < US\$320), and high (≥ 4,000,000 rupiah or ≥ US\$320), low- and middle-income households were the majority. Households using tank water (purchase/refill) as drinking water were the most frequent at 65%; the remaining households used tap and ground water which were boiled before using. Most of the households installed their own toilet (private). Households using septic tanks for toilet wastewater treatment comprised only one-quarter,

TABLE 1
Characteristics of households and caretakers (*n* = 228)

Characteristics	<i>n</i>	Proportion (%)
Education background		
Completed primary education	112	49.1
Completed senior high education	116	50.9
Occupation		
Working	52	22.8
Nonworking*	176	77.2
Monthly income (rupiah)		
< 2,000,000	133	58.3
2,000,000 to < 4,000,000	74	32.5
≥ 4,000,000	20	8.8
No response	1	0.4
Household water and sanitation		
Source of drinking water		
Tap water	60	26.3
Tank water	147	64.5
Groundwater	21	9.2
Drinking water storage		
Closed container	217	95.2
Open container	11	4.8
Toilet type		
Private	206	90.4
Shared	22	9.6
Treatment for toilet sewer		
Septic tank	60	26.3
No treatment	168	73.7
Water, sanitation, and hygiene knowledge and awareness		
Total score (median, range)		9 (6–9)
Important time for handwashing		
After using the toilet	159	69.7
Before eating	217	95.2
After eating	128	56.1
Handwashing behavior		
Always handwashing with soap	61	26.8

* Unemployed or housewife.

whereas the remaining three-quarters discarded untreated wastewater into the river directly or indirectly. More than half of the participants attained full marks of the total score on WASH knowledge and awareness. Caretakers who answered that handwashing before eating is important exceeded 95%; however, importance after toilet use was below 70%.

Table 2 shows the characteristics of children. Diarrhea and respiratory symptom prevalence in the past 2 weeks were 14.0% and 39.9%, respectively. A significant association was found between diarrhea and respiratory symptom prevalence ($P < 0.05$, χ^2 test). Children who answered that handwashing is important before eating reached 90%, but importance after toilet use was only 43%. This tendency was similar to that among caretakers. Furthermore, the handwashing skill check gave an average score of 5.0 points and a maximum score of 9.0 points, and only 11 children (5%) did not use soap.

Child nutritional status. The results of child nutritional status are shown in Table 3. The HAZ ranged from -1.27 to -1.04 , and BMIAZ ranged from -0.66 to -0.49 . The prevalence of stunting, thinness, and obesity showed that boys had higher rates in all categories ($P < 0.05$, χ^2 test). When comparing the mean BMIAZ of this study and the SEANUTS study¹⁸ with children aged 5–12 years, all values fell in between rural and urban categories (Figure 1).

Risk factors for child undernutrition and diarrhea prevalence. Tables 4 and 5 present the results of the logistic regression analysis. Being a male child (adjusted odds ratio [AOR] = 3.99; 95% confidence interval [CI] = 1.80–8.88) and not using a towel for handwashing practices (AOR = 2.37; 95% CI = 1.13–4.96) were associated with an increase in the risk of stunting. In analyzing the risk of thinness, middle-income households were associated with reduction compared with low-income ones (AOR = 0.26; 95% CI = 0.07–0.92). In terms of household environments, children from households using tap water compared with using tank water as drinking water were more likely stunting and

TABLE 3
Child nutritional status by gender ($n = 228$)

	Gender	
	Boy	Girl
Height-for-age z-scores (mean $\pm$ SD)	-1.27 ± 0.99	-1.04 ± 0.78
Body mass index-for-age z-scores (mean $\pm$ SD)	-0.66 ± 1.39	-0.49 ± 1.15
Stunting (%)	27.4	9.0
Thinness (%)	15.4	8.1
Obesity (%)	7.7	1.8

thinness (AOR = 2.26; 95% CI = 1.03–4.93; and AOR = 2.88; 95% CI = 1.13–7.35, respectively). Regarding diarrhea prevalence, children from households using open containers for water storage were associated with an increase in the risk (AOR = 5.01; 95% CI = 1.08–23.15), and being in middle-income households compared with being in low-income ones were associated with reduction (AOR = 0.36; 95% CI = 0.13–0.99).

DISCUSSION

To our knowledge, research regarding child nutritional status focused on urban slums has been carried out more frequently in India and Africa, among low- and middle-income countries. There were also some Indonesian studies focused on urban slums but mostly using relatively old data such as the Nutrition and Health Surveillance System in 2003. We compared the present study with the SEANUTS study¹⁸ conducted in 48 districts (rural and urban) of Indonesia, to evaluate the nutritional status of children in the urban slum (Figure 1). The mean BMIAZ of this study fell in between that of the rural and urban areas in the SEANUTS study. Particularly, the BMIAZ of boys in this study was almost the same as that for the rural area of the SEANUTS study. It is possible that child nutritional status in low- and middle-income countries tends to be poor in urban slums than in general urban areas. The nutritional status of Indonesian children was generally good (Figure 1). However, we need to pay attention to child nutritional status in low- and middle-income countries, especially in urban slums, because obesity rates might increase as the economic situation improves in the future.

Previous studies reported that improved water source was linked to lower risk of stunting in Africa.^{19,20} This study found that more than 85% of families used tank water or tap water as drinking water (Table 1). Between these two types of water source, tank water was associated with a reduction in the risk of stunting more than tap water (Table 4). This could be related to tap water quality, because in Bandung of Indonesia, residents purchasing bottled or refill water considered other water sources to be of poorer quality.²¹ This study revealed that water source was associated with both stunting and thinness (Table 4), indicating that tank water could improve child nutritional status.

Several studies at a household level in India⁴ and Africa²² reported that sanitation facility was associated with child nutritional status; however, there was no relation between sanitation and child nutritional status in our findings (Table 4). One possible reason is that the level of sanitation facilities in the studied area was relatively good compared with that in previous studies conducted in India and African countries. In fact, 90% of households had private toilets, and there were no

TABLE 2
Characteristics of children ($n = 228$)

Characteristics	<i>n</i>	Proportion (%)
Gender		
Boy	117	51.3
Girl	111	48.7
Grade		
Preschool	59	25.9
Grade 2	58	25.4
Grade 4	51	22.4
Grade 6	60	26.3
Disease symptoms*		
Diarrhea	32	14.0
Respiratory illness	91	39.9
Water, sanitation and hygiene knowledge and awareness ($n = 169$)		
Total score (median, range)	7 (2–8)	
Important time for handwashing		
After using the toilet	73	43.2
Before eating	151	89.3
After eating	50	29.6
Handwashing behavior ($n = 169$)		
Always handwashing with soap	47	27.8
Handwashing skills ($n = 221$)		
Checklist total score (mean $\pm$ SD)	5.0 $\pm$ 1.8	
With water and soap	210	95.0
With water	11	5.0
Using towel	158	71.5

* Two-week period prevalence.

FIGURE 1. Comparison of child nutritional status with Indonesia area (rural and urban) *South East Asian National Survey, Rural: boy ($n = 691$), girl ($n = 729$), Urban: boy ($n = 682$), girl ($n = 670$). BMI-AZ = Body mass index-for-age z-scores.

cases of open defecation in the studied area (Table 1). However, it could be different at a community level as per the suggestion of the previous studies.^{23–25} On the other hand, in this study, absence of a septic tank was not associated with stunting (Table 4). It is unlikely that the availability of septic tanks affected the nutritional status of children for each household because sewage eventually flowed into the nearby river regardless of whether a septic tank was installed or not. Although sanitation did not directly contribute to the nutritional status of children in this study, it is necessary to clarify how untreated water affects the health of children and the environment in other areas in future studies.

An estimated 50% of undernutrition is associated with the repetition of diarrhea or intestinal nematode infections caused by unsafe water, inadequate sanitation, or insufficient hygiene.²⁶ Diarrhea is caused mainly by the ingestion of pathogens but can

be prevented by handwashing.²⁷ This study found that a reduction in the risk of stunting was associated with towel usage after handwashing, but not with soap usage (Table 4). This might be because small numbers may have prevented observation of true differences, such as almost every child used soap in handwashing practices, while 71.5% of children used towels (Table 2). Another possible reason is that using a towel after handwashing has an association with the effectiveness in eliminating bacteria on hands. A previous study determined such effectiveness and revealed that the use of a clean towel after handwashing led to less *Escherichia coli* bacteria on hands than air drying.²⁸ Thus, using towels may reduce the presence of pathogens causing infectious diseases that lead to undernutrition. Moreover, the importance of the step of using towels, which the WHO incorporated into the handwashing procedure, was confirmed in this study.

TABLE 4
Factors associated with undernutrition in multivariate logistic regression analysis

Variables		Adjusted odds ratio	95% confidence interval	P value
Stunting				
Gender	Girl	1.00	—	—
	Boy	3.99	1.80–8.88	0.001
Handwashing step 10	Observed	1.00	—	—
	Not observed	2.37	1.13–4.96	0.022
Toilet sewer treatment	Septic tank	1.00	—	—
	No treatment	2.06	0.81–5.19	0.127
Drinking water	Tank water	1.00	—	—
	Tap water	2.26	1.03–4.93	0.042
	Ground water	0.55	0.11–2.65	0.453
Thinness				
Monthly income	Low	1.00	—	—
	Middle	0.26	0.07–0.92	0.037
	High	0.39	0.05–3.25	0.381
Water storage	Closed container	1.00	—	—
	Open container	2.95	0.69–12.60	0.144
Drinking water	Tank water	1.00	—	—
	Tap water	2.88	1.13–7.35	0.027
	Ground water	1.40	0.34–5.81	0.646
Gender	Boy	1.00	—	—
	Girl	0.51	0.21–1.27	0.148
Age		1.17	0.98–1.40	0.072

TABLE 5
Factors associated with diarrhea prevalence in multivariate logistic regression analysis

Variables		Adjusted odds ratio	95% confidence interval	P value
Monthly income	Low	1.00	–	–
	Middle	0.36	0.13–0.99	0.049
	High	0.32	0.04–2.58	0.284
Drinking water	Tank water	1.00	–	–
	Tap water	0.40	0.13–1.26	0.118
	Groundwater	0.77	0.19–3.10	0.716
Water storage	Closed container	1.00	–	–
	Open container	5.01	1.08–23.15	0.039
Water, sanitation, and hygiene knowledge and awareness				
Important time for handwashing	More than two choices	1.00	–	–
	One choice	2.15	0.94–4.93	0.069

In a multilevel study in developing countries, including Indonesia, high wealth was reported as a preventive factor for diarrhea in children under 5 years.²⁹ This present study showed that children from middle-income households had lower risk of diarrhea prevalence than children from low-income households (Table 5). Generally, children under 5 years old are more likely to suffer from infectious disease than those of other ages; however, this study revealed that diarrhea prevalence was higher in children older than 5 years (14.8%) than in those under 5 years (11.4%). One possible reason could be that PAUD is an additional education facility, and according to locals, families of children in PAUD had better socioeconomic status. In fact, the proportion of families with low household income is lower for preschool children (36%) than for elementary school children (67%) (data not shown). Thus, household income should receive higher consideration with regard to diarrhea prevalence regardless of the child's age.

Similar to a survey in villages of Bangladesh,³⁰ this survey revealed that appropriate water storage was associated with a reduction in the risk of diarrhea. Covered storage was less likely to be associated with high-level contamination by *E. coli*.³¹ Furthermore, in the studied area, even if there were water supply facilities within the home, the water amount to each household was insufficient. As the intermittent nature of water supply was a daily problem in the area, storing water was both common and necessary. Therefore, appropriate water storage is important to prevent contamination with pathogens in low- and middle-income countries, where water supply is inadequate.

There are few studies investigating the relationship between diarrhea prevalence and the caretaker's knowledge and awareness about WASH, but a previous study in Ethiopia reported the relation between knowledge regarding diarrhea (e.g., cause of diarrhea) and child diarrhea prevalence.³² However, no relation was found between diarrhea prevalence and the caretaker's knowledge and awareness about WASH in the present study (Table 5). This is probably because the caretaker's knowledge and awareness about WASH was generally high and there was no remarkable difference among caretakers (Table 1). Therefore, small numbers of caretaker who had relatively low knowledge and awareness level may have prevented the observation of true differences. Moreover, the diarrhea prevalence data were collected by the caretaker's recall of the previous 2 weeks rather than by an official diagnosis, so that it may affect the results.

This study has several limitations. The findings may not be generalized to all children in urban slums of low- and middle-income countries because the sample size was relatively

small, and the level of sanitation facility was generally high and almost the same in the studied area. In addition, there was the possibility of overreporting on WASH knowledge and awareness and handwashing behavior in the questionnaire survey. Considering the education level and the time to complete the questionnaires, we prioritized the ease of answering and mitigation of participants' burden. However, the simplicity of the questionnaires may have been easy for them to guess answers they were unsure of. As for the handwashing observation, it was conducted by a single researcher, to minimize observation bias. Although the presence of the researcher may have caused participants' hand hygiene behavior change as previously reported.³³ Therefore, we investigated hygiene behavior with a comprehensive approach using both questionnaire and direct observation of each child's handwashing demonstration to compensate for each other. Our findings revealed that household characteristics such as monthly income and drinking water management, as well as child hygiene practices had an association with child health. The influence of school and community environments should also be considered because children spend long hours outside their home.

In conclusion, the nutritional status of children living in an urban slum in Indonesia was generally good. Not only were household characteristics such as monthly income and drinking water source significantly associated with the nutritional status of the child, but also child characteristics such as gender and handwashing skill. On the other hand, monthly income and water storage were significantly associated with the child's diarrhea prevalence. Therefore, drinking water management at home and the proper personal hygiene practices of children are important for maintaining and promoting child health in Indonesian urban slums.

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