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Evaluating Hydration Status through Urine Specific Gravity in Children Aged 0–5 Years in Indonesia

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Abstract

This study aimed to evaluate the hydration status of preschool children aged 36–72 months in Indonesia using urine specific gravity (USG) and to compare hydration patterns between urban and semi-urban areas. A cross-sectional study was conducted from January to March 2017 among 191 preschool children in East Jakarta and Ambon Island, selected using simple random sampling. Hydration status was assessed through a 7-day USG measurement using a digital pen refractometer, while additional data on demographics, water source, and fluid intake were collected through structured interviews and dietary records. The results showed that 64.9% of children were euhydrated, whereas 35.1% were classified as dehydrated, with no significant difference between Jakarta (34%) and Ambon (36.1%) ($p = 0.886$). Although 85.9% of households had access to improved water sources, suboptimal hydration persisted, likely due to inadequate fluid intake and limited caregiver awareness. No cases of hyperhydration or severe dehydration were observed. These findings highlight that over one-third of Indonesian preschool children are affected by dehydration, emphasizing the need for regular hydration monitoring and caregiver-focused interventions

Keywords: Hydration Status, Urine Specific Gravity, Under Five Children, Indonesia

INTRODUCTION

Children possess a distinctly higher body water composition compared to adults, with water accounting for approximately 60% to 70% of their total body weight. This high water proportion underscores the vital role of adequate fluid intake in maintaining homeostasis and supporting the physiological demands of rapid growth and development (Lu et al., 2023). As such, hydration is not merely a matter of comfort or preference but a fundamental pillar in the overall health and well-being of young children. The human body relies on water to perform essential functions, including temperature regulation, nutrient transport, waste elimination, and cellular function. For children, who are in a dynamic state of development and have higher metabolic turnover, the need for consistent and adequate hydration is particularly pronounced (Bottin et al., 2019).

Over the past decade, there has been increasing recognition of hydration's impact on children's physical health, cognitive performance, and long-term disease prevention. Public health campaigns and scholarly research have emphasized the importance of water consumption from early childhood as a protective behavior against a range of negative outcomes, from minor ailments to more serious chronic conditions. Water is not only essential for maintaining immediate physiological balance but is also considered a preventive measure against obesity, dental caries, and diet-related non-communicable diseases when consumed in place of sugar-sweetened beverages (SSBs). This link between hydration and public health outcomes has captured the attention of global health authorities (Manz & Wentz, 2005; Nguyen et al., 2023).

Leading organizations, including the World Health Organization (WHO), the United States Centers for Disease Control and Prevention (CDC), the American Medical Association (AMA), and the European Food Safety Authority (EFSA), have issued specific guidelines and recommendations regarding daily water intake across different age groups. These organizations uniformly advocate for the consumption of plain drinking water and caution against the excessive intake of sweetened beverages that contribute unnecessary calories and sugars (WHO, 2015). Despite such consistent guidance, implementation and adherence to hydration recommendations remain suboptimal across

many regions of the world, particularly in low- and middle-income countries where awareness, accessibility, and behavioral factors may impede optimal water consumption. Empirical evidence from national and international research consistently points to the widespread prevalence of insufficient fluid intake among children. In the United States, a study conducted in the United States found that over half (54.5%) of children and adolescents failed to meet the daily recommended intake for water (Kenney et al., 2015). Similar findings have been echoed in a large-scale, multi-country cross-sectional study encompassing thirteen countries across three continents, which revealed that a substantial proportion of school-aged children and adolescents do not consume adequate fluids, especially plain water (Ferreira-Pêgo et al., 2015). In the Asia-Pacific region, the problem is also evident. Indonesia, a lower-middle-income country with a large young population, reports that around 30% of children do not meet the daily fluid intake recommendations, indicating a significant public health issue that requires urgent attention (Laksmi et al., 2018).

A range of factors contributes to this widespread problem. Cultural habits that prioritize solid foods over fluids, limited access to clean drinking water in certain regions, lack of education among caregivers about children's hydration needs, and the increasing availability and marketing of sugary drinks all play a role in shaping suboptimal drinking behaviors (Popkin et al., 2010). Furthermore, many early childhood education centers or daycare settings may not enforce regular drinking habits or monitor children's water intake, leading to missed opportunities for hydration throughout the day. Children, particularly in early childhood, are also less likely to recognize or verbalize thirst, making them vulnerable to dehydration even in the absence of overt symptoms. The consequences of inadequate hydration in early childhood are multifaceted. Mild to moderate dehydration can impair thermoregulation, making children more susceptible to heat stress and fatigue. Dehydration has also been associated with cognitive dysfunctions such as decreased attention span, poor memory retention, and slower reaction times (Bottin et al., 2019). Studies have documented that even a 1–2% reduction in body weight due to fluid loss can lead to measurable declines in cognitive performance, especially in tasks involving concentration, short-term memory, and problem-solving (Grandjean & Grandjean, 2007). These effects are particularly concerning in educational settings, where children's ability to learn and engage effectively can be compromised by something as simple as insufficient water intake. In addition to cognitive and physical impairments, chronic or recurring mild dehydration may pose risks for long-term health. Dehydration can lead to urinary tract infections, kidney stones, constipation, and other gastrointestinal issues. Over time, persistent dehydration may even contribute to elevated risks of developing hypertension and other cardiovascular disorders, as the body compensates for decreased fluid volume with vasoconstriction and altered blood pressure regulation. Thus, promoting hydration in childhood is not only a matter of short-term performance but also of lifelong disease prevention and health promotion (Bottin et al., 2019; Manz, 2007a).

Recognizing the need to monitor and understand hydration status more accurately, researchers have turned to the use of biomarkers that can offer objective assessments of fluid balance in children. Various methods have been employed in clinical and field settings to evaluate hydration, including plasma osmolality, saliva osmolality, urine osmolality, urine volume, and urine color charts. Among these, urine specific gravity (USG) has emerged as one of the most practical and widely used indicators, particularly in large-scale population studies and resource-limited environments. USG is a simple, cost-effective, and non-invasive measurement that reflects the concentration of solutes in urine. As such, it serves as a reliable proxy for hydration status and can be used repeatedly without discomfort to the patient. Urine specific gravity has been validated in various population groups, including athletes, hospitalized patients, and the elderly. However, its application in early childhood especially in children under five years of age has been comparatively less studied. This age group poses unique challenges in hydration assessment, including difficulties in sample collection, variability in fluid intake due to breastfeeding or mixed feeding practices, and rapid changes in renal function and fluid turnover. Despite these challenges, recent studies suggest that USG can be successfully utilized in pediatric populations with appropriate adjustments and caregiver involvement.

As such, it holds promise for improving hydration surveillance in community health programs, particularly in developing countries where laboratory-based measures may be impractical (Armstrong et al., 2012; Perrier et al., 2012; Su et al., 2006).

Indonesia, with its diverse cultural landscape and varying levels of infrastructure and health education, presents both a challenge and an opportunity for advancing the science and practice of hydration monitoring in children. Data on hydration patterns among Indonesian children under five years of age remain limited, and few studies have explored the use of USG as a feasible field measure in this context. This knowledge gap hinders the development of targeted interventions and policies aimed at improving water consumption behaviors and preventing dehydration-related health risks in early childhood. In light of these concerns, this study seeks to assess the hydration status of Indonesian children aged 0–5 years using urine specific gravity as the primary biomarker. The objectives are to evaluate the prevalence of inadequate hydration in this age group, identify potential demographic factors associated with poor fluid intake, and explore the utility of USG as a non-invasive tool for routine community health monitoring. By providing empirical data on hydration status in early childhood, the findings of this study are expected to inform future public health strategies, including caregiver education campaigns, school-based hydration programs, and national guidelines for fluid intake in young children. Ultimately, promoting adequate hydration in the formative years of life is a critical step toward fostering a healthier, more resilient generation. Through improved monitoring, education, and policy-making, it is possible to ensure that every child receives the fundamental nourishment that water provides, supporting not only their immediate development but also their future potential

RESEARCH METHODS

This study is an observational study using a cross-sectional design to evaluate hydration status through urine specific gravity (USG) among children aged 36–72 months in Indonesia. The study was conducted in preschools located in East Jakarta and Ambon Island from January to March 2017, as part of a larger research collaboration between the Faculty of Medicine, Universitas Indonesia and the Indonesian Hydration Working Group (IHWG). The population consisted of all preschool children in the selected areas, and a total of 200 respondents were selected using simple random sampling from a larger study cohort. Inclusion criteria included healthy children residing in the area for at least one year and caregivers who consented to participate.

Primary data were collected through structured interviews, 7-day fluid diary records, repeated 24-hour recalls, anthropometric measurements, and urine sample collection. Tools used included a structured questionnaire, food and fluid portion photograph books, SECA 876 digital scale, Shorr Board, and a digital refractometer for USG testing. Data were analyzed univariately to describe characteristics and hydration status of the children, while Chi Square analysis was used to see if there was proportion differences across study locations.

RESULTS AND DISCUSSION

A total of 191 preschool children from East Jakarta and Ambon were included in the final analysis after excluding nine subjects due to incomplete or erroneous data. Table 1 presents the demographic and socio-environmental characteristics of the study population. The children's age distribution shows that the majority (73.8%) were aged 4 years and older. However, this trend varied between the two study locations. In Ambon, a striking 90.7% of participants were aged four years or older, while in Jakarta, the age distribution was more balanced, with 43.6% under 4 years and 56.4%

aged 4 and older. This discrepancy may be influenced by local enrollment practices in preschools, population demographics, or differences in access to early childhood education.

The sex distribution of the children was relatively equal, with boys representing 49.2% of the sample and girls comprising 50.8%. This balance was consistent across both sites, indicating no substantial gender disparity in participation in the study. Regarding caregiver characteristics, most respondents were mothers (79.1%), followed by extended family members (15.2%), and smaller proportions of fathers (3.1%) and non-parental caregivers (2.6%). This finding is consistent with cultural norms in Indonesia where mothers generally assume primary caregiving responsibilities for young children. The respondents' age was concentrated in the 30–39-year age group (46.8%), followed by 21–29 years (28.4%) and 40 years and older (24.1%). Only one respondent was below 20 years old. This distribution suggests that the majority of caregivers were in their prime parenting age, potentially influencing their awareness and practices related to child nutrition and hydration.

Regarding environmental factors, the majority of households (85.9%) reported access to improved drinking water sources, including bottled water, piped water, and covered wells. However, when disaggregated by location, disparities were evident. In Jakarta, nearly all households (98.9%) had improved water sources, while in Ambon, this figure was notably lower at 73.2%. Conversely, non-improved water sources such as uncovered wells and rainwater were more common in Ambon (26.8%) compared to Jakarta (1.1%). Despite this difference, all respondents reported having drinking water available at home, suggesting that availability alone may not guarantee sufficient intake.

Table 1. Characteristics of Study Participant (n = 191)

Characteristics	Total		Jakarta		Ambon	
	n	%	n	%	n	%
Children						
Age						
< 4 Years Old	50	26.2	41	43.6	9	9.3
≥ 4 Years Old	141	73.8	53	56.4	88	90.7
Sex						
Boy	94	49.2	48	51.1	46	47.4
Girl	97	50.8	46	48.9	51	52.6
Respondent						
Age (n = 190)						
≤ 20 Years Old	1	0.5	0	0	1	1
21- 29 Years Old	54	28.4	30	31.9	24	25
30- 39 Years Old	89	46.8	42	44.7	47	49
≥40 Years Old	46	24.1	22	23.4	24	25
Respondent Relation with Children						
Mother	151	79.1	79	84	72	74.2
Father	6	3.1	3	3.2	3	3.1
Care Giver	5	2.6	3	3.2	2	2.1
Extended Family Member	29	15.2	9	9.6	20	20.6
Source of Drinking Water						
Improved water source	164	85.9	93	98.9	71	73.2
Non-improved water source	27	14.1	1	1.1	26	26.8

Hydration status was assessed through urine specific gravity (USG) using a digital pen refractometer, based on a single afternoon urine sample collected over a 7-day monitoring period. The mean USG across the sample was 1.017 ± 0.0059, falling within the euhydration range. Based on predefined cutoff points, USG values between 1.002–1.020 indicating normal hydration, values above 1.020 indicating dehydration, and values above 1.030 indicating severe dehydration, the results

showed that 64.9% of children were classified as euhydrated and 35.1% as dehydrated. No children were categorized as hyperhydrated or severely dehydrated.

When comparing hydration status across regions, the prevalence of dehydration in Jakarta was 34%, while in Ambon it was slightly higher at 36.1%. A chi-square test indicated that this difference was not statistically significant (*p value* = 0.886), suggesting similar hydration profiles across both urban and semi-urban settings. This finding is important because it indicates that dehydration in children is not solely determined by geographic or infrastructural differences in water access. Behavioral and knowledge-based factors, such as children's drinking habits and caregiver practices, may play a more influential role.

Table 2. Hydration Status of the Children (n = 191)

Variables	Total		Jakarta		Ambon		*p*-value
	n	%	n	%	n	%	
Hydration Status[1]							
Euhydration (Normal)	124	64.9	62	66	62	63.9	0.886
Dehydration	67	35.1	32	34	35	36.1	

[1]The hydration status were grouped from the average of 7day urine specific gravity

The prevalence of dehydration found in this study (35.1%) is lower than that reported in several studies from high-income countries. In the United States, a national survey of school-aged children showed that 63% to 66% of participants were inadequately hydrated based on urine osmolality and USG measurements. A similar study in the United Kingdom reported that 60% of children arrived at school dehydrated, while a study in France found a dehydration prevalence of 62.2% among children aged 9 to 11. These comparisons suggest that the hydration status among Indonesian preschool children, while still a concern, may be relatively better than in some Western contexts, potentially due to higher consumption of water-rich foods or cultural drinking habits.

However, it is important to interpret these findings cautiously. First, hydration status is a dynamic parameter, highly influenced by short-term behaviors, physical activity, and environmental temperature (Ekingen et al., 2022; Nerbass et al., 2021). The timing of urine collection, measurement technique, and hydration cutoffs used may vary between studies, affecting comparability. For instance, this study used afternoon urine samples, which are considered more representative of daily hydration compared to morning or spot samples, but they are still influenced by recent fluid intake. Moreover, the lack of a standardized threshold to define dehydration as a public health problem presents a challenge. Unlike indicators such as stunting or underweight, which have well-established population cutoffs, dehydration has not been clearly defined in epidemiological terms. The 35.1% prevalence observed in this study may be considered moderate but still warrants public health attention, particularly given its potential impacts on children's learning capacity, physical development, and daily functioning.

Dehydration in young children can result from both insufficient fluid intake and increased fluid loss (Bottin et al., 2019). While all households in this study reported access to drinking water, this did not necessarily translate to adequate fluid consumption by children. This discrepancy may stem from several factors. Children, especially those under five years old, have immature thirst mechanisms and may not voluntarily consume enough fluids unless prompted (Shaw & Lawson, 2008). Additionally, caregivers may not recognize the signs of mild dehydration, which can be subtle and easily overlooked. Furthermore, young children have a higher surface area-to-body mass ratio, making them more susceptible to fluid loss through insensible routes such as perspiration and respiration (Manz, 2007b). In warm and humid climates like Indonesia, the risk of dehydration due to environmental exposure is further amplified, especially for children engaging in physical activity throughout the day. Seasonal variation, such as the dry season, may also play a role, increasing baseline fluid requirements (Mora-Rodriguez et al., 2016). The role of age in hydration status is also critical. Older children tend

to have greater independence in eating and drinking behavior but may also be more influenced by preferences for sugary beverages over plain water (Wang et al., 2022). However, in this study, age did not appear to significantly affect hydration status, as dehydration prevalence remained consistent across the age groups represented.

Caregiver knowledge and beliefs about fluid needs in children are another crucial aspect to consider. Studies have shown that caregivers often underestimate the amount of water children should consume daily and may not recognize dehydration symptoms unless they are severe (Daley & Avva, 2024; Kaur et al., 2017). In Indonesia, fluid intake guidelines are available through the Ministry of Health and the Indonesian Pediatric Society (IDAI), but dissemination and implementation at the community level may be limited. There is also a cultural component. In some households, children are encouraged to eat but not necessarily drink at regular intervals. Beverages served with meals may not be water, but sweetened drinks, tea, or milk, which vary in hydration efficacy and caloric content (Prawitasari et al., 2020). This practice could partially explain why hydration remains suboptimal despite water availability.

The results of this study have important implications for public health planning. First, hydration status in young children should be more routinely monitored in primary health services, schools, and early childhood centers. Simple tools like USG measurement using refractometers can be employed by trained health workers as part of routine child health assessments. Incorporating hydration monitoring into school could help identify at-risk children early and allow for timely interventions. Second, caregiver knowledge related to hydration must be strengthened. Health promotion programs should focus not only on the importance of balanced nutrition but also on the critical role of adequate fluid intake. Educational materials should include practical guidance on daily water requirements for different age groups, signs of dehydration, and effective strategies to encourage regular drinking behavior in children. Lastly, national-level nutrition and health surveillance systems should consider including hydration-related indicators. While much attention is given to undernutrition and micronutrient deficiencies, hydration remains an under-recognized but essential element of child health. Future policies should aim to integrate hydration education into existing maternal and child health (MCH) programs and nutrition campaigns.

This study had several limitations. First, there were limited data for water content in the Indonesian food composition table, thus the completeness of the data needed to be supplemented with food composition databases from other countries. Second, there were differences in respondent backgrounds, such as education level and the nature of their relationship with the child, which may have influenced the quality and consistency of data collection.

In conclusion, this study found that more than one-third (35.1%) of preschool children in East Jakarta and Ambon were in a state of dehydration, as indicated by USG measurements. While the majority of children were adequately hydrated, the persistent prevalence of dehydration, even in households with improved water access, highlights the multifactorial nature of this issue. Addressing child dehydration requires not only infrastructure but also behavior change, caregiver education, and routine screening efforts. Given the impact of hydration on cognitive and physical development, these findings should prompt stronger emphasis on water intake as a core component of child health programs in Indonesia.

CONCLUSION

This study highlights that a substantial proportion (35.1%) of preschool children in Indonesia, specifically in East Jakarta and Ambon, were in a state of dehydration as measured by urine specific gravity. While the majority of children (64.9%) demonstrated normal hydration status, the presence of dehydration in over one-third of the sample is a matter of concern, especially considering the essential role hydration plays in children's physical, cognitive, and metabolic

functions. The findings also revealed no significant difference in hydration status between urban and semi-urban settings, suggesting that dehydration is not solely a matter of water availability but may be influenced by fluid intake behaviors, caregiver awareness, and child-specific physiological factors.

Given the dynamic nature of hydration and the absence of a standardized public health cutoff for dehydration, regular monitoring remains crucial. Urine specific gravity provides a practical, non-invasive, and cost-effective method for assessing hydration status in children and should be considered for broader implementation in both research and community health settings. Educational interventions targeted at caregivers, coupled with routine hydration assessments, are essential strategies for promoting adequate fluid intake and improving hydration outcomes in early childhood.

Future research should explore fluid consumption patterns, behavioral determinants of hydration, and potential interventions to address this preventable condition across diverse socio-economic and geographic populations.

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