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Drinking water source and gut microbiota composition in stunted children living in Jakarta slum areas, isn't related?

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Abstract

The drinking water source is one factor related to microbiota composition and stunting. This study aims to analyze microbiota composition with the source of drinking water in stunted and non-stunted children under five in the slums of Jakarta. The number of subjects in this study was 42, consisting of 21 children in the stunted group and 21 in the non-stunted group. The sources of drinking water consumed in this study were water kiosks and branded drinking water. The microbiota composition was analyzed using Next Generation Sequencing (NGS) from subject feces samples. The results showed that the group consuming branded drinking water had a higher abundance of Odoribacter splanchnicus compared to the group that consumed water from kiosks. Overall, the group that consumed drinking water from water kiosks had a higher abundance of pathogenic microbiota compared to the group that consumed branded drinking water. In addition, in the stunted group, the abundance of pathogenic microbiota was higher than in the non-stunted group. This study showed that improving the quality of drinking water sources can be a key factor in improving the nutritional status of children.

Keywords: Branded drinking water, Drinking water, Gut microbiota, Stunted children, Water kiosks, Water quality.

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1. Introduction

A fundamental human right is the availability of clean drinking water, although obtaining this resource can be difficult for many people around the world, particularly in urban slum regions [1]. In several areas of Jakarta, the capital of Indonesia, there are still slum areas that negatively impact health conditions, especially for children [2].

The high prevalence of diarrhea in slums is a result of poor sanitation, limited access to clean food and water, and other factors [3, 4]. Furthermore, slums have restricted access to health services [5]. According to previous research, there is a relationship between drinking water sources and the incidence of diarrhea [6]. In addition, children living in slums are susceptible to illnesses and infections, which pose a risk to their health and immune systems, potentially impacting their nutritional status [7, 8].

Stunting remains a major public health issue in Indonesia, particularly in major cities like Jakarta. World Health Organization [1] reports that thirty percent of Indonesia's under-five children suffer from stunting, making it one of the worst countries in Southeast Asia [9]. The same issues persist in Jakarta, especially in the slum regions where there is little access to clean water, poor sanitation, and limited healthcare [10, 11]. According to a UNICEF Indonesia study (2012), children living in informal settlements face an increased risk of malnourishment and stunting due to several interrelated causes [2].

According to recent studies, children's development and general health are greatly influenced by the gut microbiota, a complex community of microorganisms that live in the digestive system [12, 13]. Immune system performance, pathogen defense, and nutrient absorption are all significantly influenced by the gut flora [14]. However, environmental conditions, such as water quality, can have a major impact on its composition [15, 16]. Several studies on the relationship between drinking water sources and microbiota composition are still limited, especially in child subjects [17, 18].

The aim of the present study was to analyze the relationship between drinking water sources and microbiota composition in stunted and non-stunted children in slum areas of Jakarta. This study seeks to find possible connections between environmental factors and child health outcomes by evaluating the sources of drinking water that are accessible and examining the microbial communities that exist in the gut. The results may help guide public health initiatives and policies that target vulnerable groups facing malnourishment and stunting while also enhancing water quality.

2. Materials and Methods

2.1. Study Protocols and Participants

This study is part of a study on the composition of the microbiota in stunted dan non-stunted and related contributing factors [19]. This cross-sectional study was conducted in Urban Village, a slum area in North Jakarta. The study comprised 42 children aged 2 to 5 years, who were split into two groups: non-stunted ($-2SD \leq HAZ < 3SD$) and stunted ($HAZ \leq -2SD$). None of the children had taken antibiotics in the month prior to the stool tests. The University of Indonesia's Faculty of Medicine's Ethical Committee approved the study protocol, which was assigned reference number KET 22/UN2.F1/ETIK/PPM.00.02/2021.

2.2. DNA Extraction, and 16S rRNA Sequencing, and Gut Microbiota Composition

This analysis is the same as in previous studies [19]. The mothers of subjects were given DNA/RNA Shield Fecal Collection Tubes to use in order to gather stool samples. The samples were stored at room temperature since the DNA/RNA ShieldTM Fecal Collection Tube ensures sample stability under ambient conditions. The DNA/RNA ShieldTM reagent effectively lyses samples and renders pathogens inactive. DNA was extracted using the PrestoTM Stool DNA Extraction Kit Protocol from Geneaid. The A260/A280 ratio, which is used to gauge DNA purity, was 1.8 to 2.0. The Illumina MiSeq System was utilized for 16S rRNA metagenomic sequencing after the V3–V4 region of the 16S rRNA gene was amplified by PCR in accordance with NGS Meta-genomic Amplicon Sequencing protocols

Gut Microbiota Composition R Studio and QIIME (http://www.qiime.org) were used for the computational studies. The default configurations in QIIME were used for quality filtering. Based on 97% identity, reads were categorized into operational taxonomic units (OTUs). Using the Silva database as a guide, the representative sequences were categorized, and taxonomy was added to the OTU table. OTUs and singletons with an abundance of less than 0.005% were eliminated. Using linear discriminant analysis (LDA) effect size (LEfSE), microbiological differences between the stunted and non-stunted groups were investigated. The study utilized the Kruskal–Wallis rank sum test to detect features that differed among the taxa allocated. Subsequently, LDA was utilized to measure the effect size of each feature, with significance being established at an alpha value of less than 0.05.

2.3. Statistical Analysis

The Statistical Program for Social Sciences (SPSS) version 20.0 was used to analyze the data. Univariate data were displayed, including the composition of the gut microbiota and the characteristics of the drinking water source. Using the Independent T-test, the relationship between the makeup of the gut microbiota and the source of drinking water was examined.

3. Results

3.1. Source of Drinking Water

Most participants in both the stunted and non-stunted groups used refill water from the water kiosk, depending on the source of drinking water. In contrast to the stunted group (14.3%), the non-stunted group used more branded drinking water (38.1%). Table 1 shows the subjects' distribution according to their drinking water source.

Table 1.
Source of drinking water in a stunted and non-stunted group.

Source of Drinking Water	Stunted (n=21)	Non-Stunted (n=21)	*p*-Value[1]
Water Kiosks	18(85.7)	13(61.9)	0.083
Branded Drinking Water	3(14.3)	8(38.1)	

[1] *Analyzed by Chi-Square Test*

3.2. Composition of Gut Microbiota in Stunted and Non-Stunted Group

The microbiota composition of the non-stunted and stunted groups is displayed in Table 2. Several bacteria have been reported in previous studies [19]. More pathogenic bacteria, including *Escherichia coli*, Enterococcus, Mitsuokella, and *Providencia alcafaciens*, were generally present in the stunted group. On the other hand, beneficial bacteria including Bifidobacterium, Lactobacillus, Blautia, *Odoribacter splanchnicus*, and *Akkermansia muciniphila* were more prevalent in the non-stunted group.

Table 2.
Composition of Gut Microbiota in Stunted and Non-Stunted Group.

	Abundance (OTU)		
Microbiota	**Stunted**	**Non-Stunted**	***p*-Value[1]**
Bifidobacterium	59.352	98.071	0.148
Lactobacillus	1973	7126	0.678
Enterococcus	181	76	0.052
Escherichia coli	19.225	17.324	0.554
Blautia [19]	11.550	20.755	0.016
Lachnospiraceae [19]	2601	6134	0.048
Monoglobus [19]	183	484	0.030
Bilophila [19]	10.790	12.417	0.031
Mitsuokella [19]	24.469	2847	0.037
Alloprevotella [19]	23.952	7888	0.049
Akkermansia muciniphilla [19]	405	1116	0.012
Odoribacter splanchnicus [19]	32.747	42.993	0.040
Bacteroides clarus [19]	7772	8900	0.045
Providencia alcalifaciens [19]	861	353	0.023

[1] *Analyzed by the Independent t-Test.*

3.3. Gut Microbiota and Source of Drinking Water

The composition of the microbiota was examined in this study in relation to the use of various drinking water sources (Table 3). Beneficial bacteria such as Bifidobacterium, Lactobacillus, Blautia, Lachnospiraceae, Monoglobus, Alloprevotella, Akkermansia muciniphila, Odoribacter splanchnicus, and Bacteroides clarus were found to be more abundant in the participants who drank branded drinking water, according to the analysis. Odoribacter splanchnicus was found to differ significantly in the statistical tests, with a p-value of 0.021.

Table 3.
Gut Microbiota and Source of Drinking Water.

Microbiota	**Source of Drinking Water**		***p*-Value**
	Water Kiosks	**Branded Drinking Water**	
Bifidobacterium	3242	5217	0.555
Lactobacillus	130	462	0.455
Enterococcus	7	4	0.803
Escherichia coli	926	716	0.261
Blautia	4394	4911	0.490
Lachnospiraceae	56	75	0.473
Monoglobus	136	145	0.509
Bilophila	263	256	0.806
Mitsuokella	248	106	0.193
Alloprevotella	1730	535	0.152
Akkermansia muciniphilla	1079	2608	0.405
Odoribacter splanchnicus	412	599	0.021
Bacteroides clarus	115	53	0.234
Providencia alcalifaciens	9	5	0.220

[1] *Analyzed by the Independent t-Test.*

4. Discussion

This study focuses on the relationship between drinking water sources and microbiota composition. In this study, drinking water sources were divided into water kiosks and branded drinking water. We all understand that branded drinking water is standardized according to government food and beverage regulations. While drinking water from water kiosks is a non-regulated refilled bottle/gallon, we do not know where the water comes from and what the health quality of the bottle/gallon is. The results showed that there were differences in microbiota abundance between the water kiosk and branded drinking water groups. The bacteria that was significantly different in the two groups was Odoribacter splanchnicus, where the abundance was higher in the group consuming branded drinking water. This study is similar to a study on drinking water sources and microbiota composition conducted in Nicaraguan children, which showed that children from households with high total coliforms in drinking water had many pathogenic bacteria such as Bdellovibrionales, Treponema genus, and Vibrio [20].

The source of drinking water is one of the many variables that can lead to stunting. Wells, water kiosks, and the Jakarta Water Management Domestic Pipe (PAM) were the main sources of drinking water for the residents of the slum area [21]. In the present study, the sample water that the subjects used was from branded drinking water and water kiosks. The source of drinking water in the stunted group came more from water kiosks compared to the non-stunted group, who tended to consume more drinking water from branded sources.

Sources of drinking water are often associated with cases of malnutrition in children under five [22, 23]. One of the factors that can be linked to the occurrence of stunting in Jakarta is the poor quality of drinking water. Due to a lack of a ccess to clean, safe drinking water, many locals rely on contaminated water sources, such as untreated groundwater and contaminated rivers [2]. Recurrent infections and diarrheal illnesses caused by exposure to this contaminated water are major contributors to malnutrition and impaired nutritional absorption, which are significant causes of stunting [15]. Since poor water quality has a direct negative impact on children's health and development, studies have demonstrated that improving WASH conditions is essential for lowering stunting rates [24]. In line with this, a recent study found that, compared to non-stunted groups, the number of subjects who consumed branded drinking water was higher in the stunted group.

Children who are exposed to hazardous microorganisms and chemicals through contaminated water may experience stunted growth, malnutrition, and an increased vulnerability to waterborne infections, among other poor health outcomes. On the other hand, better sanitation and access to water can have a major positive influence on the growth, comfort, and general well-being of children [25].

The results of this study showed that whereas the non-stunted group had a larger abundance of beneficial bacteria, the stunted group had a higher abundance of pathogenic bacteria. As in previous studies, the group of stunted children had many microbiota, including Enterococcus, Escherichia coli, Alloprevotella, and Mitsuokella. In contrast, the group of non-stunted children was dominated by good bacteria such as Bifidobacteria, Lactobacillus, Odoribacter splanchnicus, and Akkermansia muciniphila [19]. This is in line with several previous studies showing that in the group of malnourished children, more pathogenic bacteria were found compared to the group of healthy children [26, 27].

There are many factors that influence the composition of microbiota, one of which is related to hygiene, sanitation, and drinking water sources [3, 15, 28, 29]. Since newborns are particularly susceptible to the negative effects of polluted water, it is especially important to ensure safe drinking water throughout the vital period from weaning to the forma tion of a full immune system [30]. Dependence on shallow groundwater, which is frequently contaminated, is widespread in low-income urban settings, putting local residents at risk for health problems [31].

Having access to clean drinking water can have a significant impact on society as well as on people's individual health. Enhanced water accessibility is linked to better comfort, safety, dignity, and convenience for households [25].

The composition of the gut microbiota is greatly influenced by the source and quality of drinking water, and this has a substantial effect on general health and development, particularly in children. The equilibrium of the gut microbiota is disrupted when contaminated water sources, which are frequently present in urban slum areas, introduce a range of diseases and harmful bacteria into the digestive tract [15]. This imbalance can result in diseases like environmental enteropathy, which weakens the immune system and impairs the absorption of nutrients, thereby causing malnourishment and stunting [12].

In this study, it was found that the group consuming drinking water from water kiosks was dominated by pathogenic bacteria such as Enterococcus [32], Escherichia coli [33], Mitsuokella Harper, et al. [34], and Providencia [35, 36]. In contrast, the group consuming drinking water from branded sources was dominated by beneficial bacteria such as Bifidobacterium [37], Lactobacillus [38], Akkermansia muciniphila Si, et al. [39], and Odoribacter splanchnicus [40]. The results of the study also showed that for Odoribacter splanchnicus, there was a significant difference between the water kiosk group and the branded drinking water group.

Odoribacter splanchnicus is an anaerobic bacterium of the Bacteroidetes phylum. It is frequently identified in the gut microbiota of humans [40]. Recent research has indicated a connection between several health outcomes, including children's growth and development, and the presence and quantity of gut bacteria, such as Odoribacter splanchnicus. Studies have shown that malnutrition and stunting may be linked to an imbalance in the gut microbiota, which is frequently characterized by a decrease in beneficial bacteria such as Odoribacter splanchnicus [41]. The fermentation of dietary fibers into short-chain fatty acids (SCFAs), which are essential for gut health and nutrient absorption, is the function of this bacterium. A decreased quantity of Odoribacter splanchnicus has been linked to several illnesses, including inflammatory bowel disease (IBD), cystic fibrosis, and non-alcoholic fatty liver disease [40]. Stunting can also result from a lack of Odoribacter splanchnicus and other SCFA-producing bacteria, which can likewise cause nutrient malabsorption and compromised gut barrier function [42].

Based on the findings of this study, the quality of drinking water sources plays an important role in the composition of gut microbiota in stunted children. The group of children who consumed drinking water from water kiosks had a higher number of pathogenic microbiota compared to the group who consumed branded drinking water, as seen in the differences in the presence of Escherichia coli and Providencia alcalifaciens bacteria. The presence of these pathogenic microbiota can affect the digestive system and nutrient absorption, which contributes to malnutrition and stunting problems. The clinical implications of these findings suggest that improving the quality of drinking water sources can be a strategic step in enhancing the nutritional status of children, especially in areas with limited access to clean water. Efforts to improve sanitation and better water access are urgently needed to support optimal growth and development in children, as well as to reduce the prevalence of stunting in vulnerable communities.

The strength of this study lies in its focus on the stunted group in one of the slum areas in Jakarta. Research on the relationship between drinking water sources and microbiota composition is still limited. However, this study has a weakness, namely that no analysis was carried out on the content of the drinking water sources used by the research subjects.

5. Conclusions

In the present study, the stunted group had a higher abundance of harmful bacteria. One factor related to microbiota composition in this study is the source of drinking water. The group consuming branded drinking water had a higher abundance of the bacterium Odoribacter splanchnicus compared to the group consuming water from a water kiosk. Thus, maintaining a balanced gut microbiota while addressing water quality issues is therefore a critical component of public health strategies aimed at improving nutrition and growth, particularly in vulnerable populations such as children in urban slums.

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