Research Paper

Association between water, sanitation, and hygiene practices (WASH) and anthropometric nutritional status among selected under-five children in rural Noakhali, Bangladesh: a cross-sectional analysis

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ABSTRACT

This study aims to find out how WASH practices may be responsible for the development of diarrheal disease and poor physical growth of under-five children in rural Noakahli, Bangladesh. A case study was conducted among 110 households who had children aged between 0 and 59 months chosen by simple random method at Noakhali district, Bangladesh. Bivariate and multivariate logistic regression was employed to find the association. About 40.1% of children had diarrhea within 1 week prior to the study and 38.9% had skin problems of different kinds. A significant association between wasting and hand washing before feeding the baby ($p < 0.006$) was found; stunting and family income also showed association ($p < 0.003$). Bathing the baby regularly, cleaning toilets, and cleanliness of the baby was found to be strongly associated; not cleaning toilets was associated with a very high risk of getting diarrhea (AOR: 16.397 (1.075–250.013)). Moreover, the unavailability of soaps in toilets increased the risk of diarrheal diseases (COR: 3.933 (1.258–12.296)) in the study population. Malnutrition is highly prevalent in children living in the study area and needs to be addressed by considering the factors which affect this rate.

Key words | Bangladesh, hygiene and sanitation practice, nutritional status, under-five children

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HIGHLIGHTS

- Around 46.3%, 51.9%, and 28.7% of the children were underweight, stunted, and wasted respectively which is much higher than the national statistics of malnutrition in Bangladesh.
- All the respondents used tube well water for drinking, however, most of them used other sources of water for household chores.
- Personal hygiene of the child as well as the household hygiene strongly associated with very high risk of getting diarrhea.
- Unavailability of soap is also a risk factor of getting diarrhea of the child.

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INTRODUCTION

Infants and young children are affected by the multifaceted problem of nutritional deficiencies globally, even though much attention has been given to tackle the deficiencies in the last few decades (UNICEF 2015). Different conceptual frameworks determined the causes of undernutrition and were found to be multifactorial and interlinked by describing the immediate, underlying, and basic causes of malnutrition (UNICEF 2013). Being vulnerable to infections, children are given special attention, though the highest proportions of infections among children occur due to poor water, sanitation, and hygiene (WASH) related diarrheal and parasitic diseases. Globally, there are nearly 1.7 billion cases of childhood diarrheal disease every year and diarrhea is responsible for killing around 525,000 children every year (WHO 2006). In 2009, about 3.5 billion people world wide, most of them children, were infected by intestinal parasites caused by helminths and protozoa (Brooker *et al.* 2009).

Diarrhea, parasitic infections, and environmental enteropathy (EE) are key mediating pathways linking poor WASH to developmental deficits (Bhutta *et al.* 2008; Brown *et al.* 2013; Gizaw & Worku 2019). A large body of evidence suggests that malnutrition is linked with poor WASH practice (Pruss-Ustun & WHO 2008; Langford *et al.* 2011; Spears 2013). Diarrheal deaths and prevalence of diarrheal diseases among children under the age of five have been declining around the world. However, many diarrheal disease cases still can be found, which illustrates the necessity of continuous research and development (Talukder 2017). To mitigate morbidity and mortality due to diarrheal diseases, it is necessary to direct global attention to improving access to safe drinking water and enhance the sanitation and hygiene conditions among vulnerable communities (Montgomery & Elimelech 2007; Prüss-Ustün *et al.* 2014; Abuzerr *et al.* 2020).

One study reported that children living in unsanitary and unhygienic environments may become undernourished even in the absence of diarrhea or intestinal worms (Humphrey 2009). A child may develop a condition known as environmental enteropathy due to repeated ingestion of fecal bacteria. Consequently, it may overload the gut and cause malabsorption, leaking mucosa, poor villi functioning, and inflammation of gut cells that may lead to body faltering (Ngure *et al.* 2014; Burton *et al.* 2015). One study conducted in Gaza Strip revealed that the availability of sewage water around the household increases the risk of acute diarrhea. The study concluded that a closed sewerage system coupled with a clean safety tank and good handwashing practice before and after eating could significantly reduce acute diarrhea in under-five children (Abuzerr *et al.* 2020), which shows the significance of WASH in the control of diarrhea. Diarrhea has very strong implications on poor infant and child growth though the effect of diarrhea on chronic undernutrition is still a matter of debate since many other factors may confound the association (Mahmud & Mbuya 2016).

Bangladesh, a densely populated developing country in South Asia, has experienced rapid demographic and epidemiological transition over the past few decades and is facing paradoxical health challenges related to the high prevalence of both underweight and overweight problems among under-five children (Hossain Khan & Hayder Talukder 2013). According to the Bangladesh Health and Demographic Survey (BDHS) 2017, 22% of under-five children are underweight, 8% are wasted and 31% of them are stunted. The survey report also postulates that 5% of the children experienced diarrheal disease in the last two weeks of the survey (NIPORT 2019). Growth faltering in children due to poor WASH practices has also been reported in another study conducted in Bangladesh. The study posits that caregivers, poor WASH practices have a strong association with the frequency of diarrheal diseases in children, and good caring practice can minimize the risks (Talukder 2017). The relationship between WASH practices and diarrheal diseases may influence the development of chronic undernutrition and to analyze this critical relationship, the study aims to assess the association of different WASH practices with the frequency of diarrheal disease and different indicators of nutritional status in under-five children of Noakhali district, Bangladesh. This two-way pathway may be helpful to understand the complex process of whether WASH practices effect the development of diarrheal disease as well as the overall growth of children or not.

METHODOLOGY

Study design and study population

The study was cross-sectional in nature. The study duration was from December 2019 to February 2020 in Bangla bazar, Sadar Upazilla, Noakhlai, Bangladesh. The area was selected randomly among rural villages and the households were also chosen randomly from the villages, however, it cannot be claimed to be representative of the total population. A total of 110 housesholds were chosen randomly with mother/caregiver and children pairs from Noakhali, who willingly agreed to participate in the study. The calculation of sample size used Cochrane's equation having a precision level at 0.1, 90% confidence limit, and 31% as probability fraction (according to the BDHS, the undernutrition rate in Bangladesh is 31%) (NIPORT 2019) and a design effect of 1.7. The sample size was calculated using the Cochran formula (Israel 1992), $n_o = \frac{z^2(1-P)P}{d^2}$. After adding a 10% non-response rate the minimum sample size of the study was 107; however, information from 110 households was finally collected. The study considered under-five children since they are mostly dependent. Their hygiene and sanitation practices depend on mothers/caregivers' practice; hence the main respondents were mothers/caregivers and they were asked how they maintain and practice basic hygiene and sanitation relating to their child. As the children spend most of the time with their mother and the mother is typically the primary caretaker of the family; therefore, children's hygiene ad sanitary practices are mostly dependent on the mother (Vivas *et al.* 2010; Ghosh *et al.* 2020).

Data collection tools and techniques

A questionnaire was developed containing closed-ended questions to obtain relevant information on socioeconomic, anthropometric, sanitation, and hygiene practice. All questions were designed, pre-tested, modified, and adjusted. The purpose of the pre-test was to test the content, working expression, the topical sequence of questions, duration of the interview, and the reliability of some items. After pretesting the individual questionnaire, which was related to quantitative data, was improved and reformed to ensure content coverage, reliability, and validity of the study.

Age detection

The age of the subjects under study was determined by interrogation and confirmed through probing. The age of the children was collected from parents, and they were asked to bring the children's birth certificate or immunization card. If parents were unable to say the exact age of their children, then additional probing was carried out. For instance, if they can remember any national events or religious programs when their child was born.

Measuring body weight

Weight was recorded in kilograms by using a standard weighing machine. During measuring the children's weight, each subject was barefooted and heavy clothing was removed to measure the exact weight. If a child was unable to stand then the mother took the child in her lap and later the mother's weight was deducted. The measurements were taken twice and sometimes three times if the difference between the consecutive two measurements was too large.

Measuring height

For measurement of height, subjects were positioned to stand on the platform, barefoot, with their head upright, looking straight forward by using a standard height measurement scale. Height was measured to the nearest 0.1 cm. A length measuring board was used if a child was unable to stand or was below two years of age. The measurements were taken twice and sometimes three times if the difference between the consecutive two measurements was too large.

Data verification

Standard procedures in measurements were applied carefully in every stage of measurements. Questionnaires were checked each day after interviewing and again these were carefully checked after completion of all data collection and coded before being entered on to a computer. To

minimize errors, all the data were checked for consistency and outliers and corrected accordingly.

Assessment of nutritional status

The nutritional status of school children was assessed by anthropometric measurements, i.e. height in centimeters (cm) and weight in kilograms (kg). It was determined by Z-score value according to WHO classification (WHO 2006). Definition of anthropometric nutritional status:

- Weight for age Z-score (WAZ) or underweight: Weight-for-Age Z Score (WAZ) should be understood as the number of standard deviations of the actual weight of a child from the median weight of the children of his/her age as determined from the standard sample.
- Height for age Z-score (HAZ) or stunting: A Height-for-Age Z Score (HAZ) should be understood as the number of standard deviations of the actual height of a child from the median height of the children of his/her age as determined from the standard sample.
- Weight for height Z-score (WHZ) or wasting: A Weight-for-Height Z Score (WHZ) should be understood as the number of standard deviations of the actual weight of a child from the median weight of the children of his/her age as determined from the standard sample.

According to the 2006 WHO growth standards with new cut-offs for children aged 0–59 months, the 5th and 95th percentiles of the SDs were 1.35 and 1.95 for HAZ, 1.17, and 1.46 for WAZ, 1.08 and 1.50 for WHZ (WHO 2006).

Assessment of hygiene and sanitation practices

Some basic hygiene practice-related questions were asked, for example type of toilets, cleaning materials for handwashing and how frequently they are used, source of water, cleanliness of body, etc.

The occurrence of diarrheal disease

Respondents were asked if the child had experienced any diarrheal disease within the last week (of the survey). Developing diarrheal disease in the last week prior to the survey was considered as poor maintenance of household hygiene and sanitation though a critical link cannot be developed since a cause-effect relationship is difficult for a cross-sectional study.

Outcome and predictor variables

The primary outcomes of the study were the occurrence of diarrheal disease within the last week of the survey and also the indicators of nutritional status (underweight, stunting, and wasting). The predictor variables were WASH practices and various socio-demographic variables that can affect the association. The two-way pathway was created in a sense that the effect of WASH variables may be difficult to observe directly in the development of poor physical growth of under-five children since many factors may confound the situation. The most prevalent consequence of poor WASH practices is diarrhea, which has been considered to study. It may give clear identification of how diarrheal disease development in the children has been influenced by poor household practices.

Data analysis and variable information

Data were processed and analyzed statistically by using SPSS software version 23. Descriptive statistics for water, hygiene, and sanitation practices, along with some basic socio-demographic characteristics of the study population, were performed. To assess the effect of socio-economic variables on children's anthropometric status, a Chi-square test was performed. The frequency of diarrheal diseases and its effect on anthropometric status was also assessed. Binary and multivariate logistic regression was performed to assess how various sanitation and hygiene practices contributed to the development of recent diarrheal diseases. The odds ratio was determined and is reported in the Results section, with 90% CI and a p-value of <0.1 was considered statistically significant.

Ethical consideration

Ethical permission was taken from the ethical board of Noakhali Science and Technology University, Bangladesh. Consent from the respondents was also taken before the study. All the international standards of ethical rules and regulations were maintained.

RESULTS

Socio-demographic and anthropometric characteristics

Table 1 summarizes the socio-demographic characteristics of all the children included in this study. A total of 108 children of age group 1–59 months were included in the study and from the table it can be seen that 55 (50.9%) were boys and the rest 53 (49.1%) were girls. It was also found that 53 (49.1%) families consisted of four or less children and 55 (50.9%) families consisted of five or more children. The study also identified that about 40.7 and 17.6% of fathers and mothers were illiterate respectively. In the case of education, only 6.5 and 5.6% of fathers and mothers received higher secondary education. In the case of the father's occupation, most of them (66.7%) were day laborers and only 8.3% were government employees. Most of the families (38%) had an income of between 10,000 and 15,000 BDT, though 32% had an income of less than 10,000 BDT.

By analyzing anthropometric data, it was found that about 46.3% of children were underweight, whereas more than half (51.9%) of the children were stunted, and only 28.7% of children were wasted. The study showed that malnutrition was higher in boys than girls; 29.1% of boys were wasted and 28.3% of girls were wasted. The prevalence of underweight among boys was 47.3% while 45.3% of girls were underweight; 44.7% of the children were found to have diarrhea within the last 7 days of the survey, whereas 38.9% had skin diseases and 23.1% had teeth decay.

Water, sanitation, and hygiene (WASH) among the respondents

Table 2 shows that about 83.3% of families had a sanitary toilet in their house. About 92.6% of children used sandals (footwear) in the bathroom, and the rest of them did not use any. The study also found that about 95.4% of children washed their hands after using the toilet, in which 85.2% of children used soap and the rest of them used other (ash/soil) materials for washing their hands. In the present study, we found that all the children washed their hands before eating a meal and 76.9% of children used soap. In

Table 1 | Descriptive statistics of respondents

Variable name	Frequency (%)
Size of the family	
Four or less	53 (49.1)
Five or more	55 (50.9)
Sex of the child	
Boys	55 (50.9)
Girls	53 (49.1)
Education of the father	
Illiterate	44 (40.7)
Primary	38 (35.2)
Secondary	19 (17.6)
Higher secondary	7 (6.5)
Education of the mother	
Illiterate	19 (17.6)
Primary	48 (44.4)
Secondary	35 (32.4)
Higher secondary	6 (5.6)
Occupation of the father	
Day laborer	72 (66.7)
Farmer	11 (19.2)
Government employee	9 (8.3)
Business	16 (14.8)
Monthly family income	
< 10,000	32 (29.6)
10,000–15,000	41 (38)
> 15,000	35 (32.4)
Weight for age (underweight)	
Normal	57 (52.8)
Underweight	50 (46.3)
Overweight	1 (0.9)
Height for age (stunted)	
Normal	52 (48.1)
Stunted	56 (51.9)
Over nourished	0 (0.00)
Weight for height (wasted)	
Normal	64 (59.3)
Wasted	31 (28.7)
Over nourished	13 (12)
Having diarrhea 1 week before survey	
< 1 week	44 (40.7)
Not affected	64 (59.3)

(*continued*)

Table 1 | continued

Variable name	Frequency (%)
Skin disease	
Yes	42 (38.9)
No	66 (61.9)
Child tooth decay	
Yes	25 (23.1)
No	83 (76.9)

Table 2 | Frequency distribution of WASH variables

Variable	Frequency (%)
Knowledge of hygiene practices	
Yes	104 (96.3)
No	4 (3.7)
Types of toilet	
Sanitary	90 (83.3)
Unsanitary (open/hanging)	18 (16.7)
Use of shoes in the bathroom	
Yes	100 (92.6)
No	8 (7.4)
Wash hands after toilet	
Yes	103 (95.4)
No	5 (4.6)
Materials for hand washing	
Soap	92 (85.2)
Other (ash/soil)	16 (14.8)
Soap available in the toilet	
Yes	92 (85.2)
No	16 (14.8)
Clean the toilet regularly	
Yes	99 (91.7)
No	9 (8.3)
Frequency of cleaning toilet	
3–7 days	82 (75.9)
After 7 days	26 (24.1)
Food covered all the time	
Yes	107 (99.1)
No	1(0.9)
Wash hands before feeding the baby	
Yes	80 (74.1)
No	28 (25.9)
Source of drinking water	
Tube well	108 (100)
Pond and others	0 (0)
Time of hand washing	
Before meal	108 (100)
After meal	0 (0)
Hand washing materials	
Soap	83 (76.9)
Nothing	25 (23.1)
Brushing child's teeth regularly	
Yes	72 (66.7)
No	14 (13)
Has not started	22 (20.4)
Frequency of tooth brushing	
Once per day	65 (60.2)
Twice per day	7 (6.5)
No	14 (13)
Has not started	22 (20.4)
Bath child regularly	
Yes	91 (84.3)
No	17 (15.7)
Clean state of the baby	
Yes	61 (56.5)
No	47 (43.5)
Presence of long nails	
Yes	73 (67.6)
No	35 (32.4)
Roaming outside without shoes	
Yes	55 (50.9)
No	53 (49.1)
Source of cooking water	
Tube well	4 (4.6)
Pond	103 (95.4)
Food covered all the time	
Yes	107 (99.1)
No	1 (0.9)
Source of domestic water	
Tube well	3 (2.8)
Pond	105 (97.2)

terms of brushing teeth, 65 (60.2%) brushed their teeth once dail while 7 (6.5%) brushed twice daily. In Table 3 it is reported that about 84.3% of children bathed every day.

It was reported in the present study that more than half of the children (about 56.5%) were in a clean state. In the case of basic hygiene practice, 67.6% of children had long nails. About half of the children (50.9%) used sandals all day. All the households were using tube wells for drinking water and 97.2% of households' respondents reported that they depended mainly on pond water for domestic purposes.

Table 3 discusses the relationship between different demographic variables, diarrhea, and the handwashing practice of mothers with the children's anthropometric status. There was no significant relationship between the parent's education and the nutritional status of the child. However, the descriptive statistics showed that the children's nutrition status improved with the increasing educational level of the mother to some extent.

In the present study the nutritional status of the children was found to be better than the children whose mother did not wash her hands before feeding the baby. There was a strong relationship between the handwashing practice of the mother and the nutritional status of the child.

Monthly income is one of the important indicators to describe the nutritional status of the children. The relation between monthly income of the family and HAZ score was found to be significant and an increasing family income decreased the stunted percentage of the under-five children.

In Table 4, the association between the occurrence of diarrhea and personal hygiene were identified in terms of bivariate analysis with crude odds ratio (COR) and the adjusted odds ratio (AOR) and 95% confidence interval was used (CI). It was found that those who used ash or soil as a handwashing material had 0.254 times (0.081,0.795; 95% CI) higher tendency to have diarrhea than the children who had used soap. The frequency of cleaning toilets was also found to have an association with diarrheal disease cases. Another strong association between bathing a child regularly and skin diseases were found. It

Table 3 | Relationship of anthropometric nutritional status with socio-demographic variables and diarrheal diseases (chi-square test)

	WAZ			HAZ			WHZ		
Variables	**Normal**	**Underweight**	***P* value**	**Normal**	**Stunted**	***P* value**	**Normal**	**Wasted**	***P* value**
Sex of child									
Boy	28 (50.9%)	26 (47.3%)	0.588	27 (49.1%)	28 (50.9%)	0.497	34 (61.8%)	16 (29.1%)	0.626
Girl	29 (54.7%)	24 (45.3%)		25 (47.2%)	28 (52.8%)		30 (56.6%)	15 (28.3%)	
Educational status of the mother									
Illiterate	9 (47.4%)	10 (52.6%)	0.772	10 (52.6%)	9 (47.4%)	0.970	11 (57.9%)	8 (42.1%)	0.118
Primary	28 (58.3%)	19 (39.6%)		23 (47.9%)	25 (52.1%)		24 (50.0%)	14 (29.2%)	
Secondary	18 (51.4%)	17 (48.6%)		16 (45.7%)	19 (54.3%)		24 (68.6%)	8 (22.9%)	
Higher	2 (33.4%)	4 (66.7%)		3 (50.0%)	3 (50%)		5 (83.3%)	1 (16.7%)	
Hand washing practices									
Yes	42 (52.5%)	37 (46.2%)	0.838	40 (50.0%)	40 (50%)	0.334	52 (65%)	23 (35.0%)	0.006*
No	15 (53.6%)	13 (46.4%)		12 (42.9%)	16 (57.1%)		12 (60.0%)	8 (40.0%)	
Monthly income of the family									
<10,000	13 (40.6%)	19 (59.4%)	0.204	8 (25%)	24 (75%)	0.003*	15 (46.9%)	9 (28.1%)	0.063
10,000–15,000	21 (51.2%)	19 (46.3%)		21 (51.2%)	20 (48.8%)		24 (58.5%)	14 (34.1%)	
>15,000	23 (65.7%)	12 (34.3%)		23 (65.7%)	212 (34.3%)		25 (71.4%)	8 (22.9%)	
Having diarrhea									
Less than one week before survey	26 (24.1%)	18 (16.7%)	0.425	23 (21.3%)	21 (19.4%)	0.303	25 (23.1%)	12 (11.1%)	0.591
Not affected	31 (28.7%)	32 (29.6%)		29 (26.9%)	35 (32.4%)		39 (36.1%)	19 (17.6%)	

*$p < 0.05$.

Table 4 | Association of occurrence of diarrhea with personal hygiene variables

	Having diarrhea 1 week before survey		
Variable name	**N (%)**	**COR (95% CI)**	**AOR (95% CI)**
Types of toilet			
Sanitary	36 (33.3)	1	1
Unsanitary (open/hanging)	8 (7.4)	0.833 (0.30–2.313)	2.0 (0.489–8.184)
Use of shoes in bathroom			
Yes	40 (37)	1	1
No	4 (3.7)	1.50 (0.355–6.347)	0.351 (0.33–3.693)
Materials for hand washing			
Soap	33 (30.6)	1	
Other (ash/soil)	11 (10.2)	0.254 (0.081–0.795)*	
Soap available in the toilet			
Yes	33 (30.6)	1	1
No	11 (10.2)	3.933 (1.258–12.296)*	3.179 (0.748–13.54)
Clean toilet			
Yes	36 (33.3)	1	1
No	8 (7.4)	14 (1.682–116.496)**	16.397 (1.075–250.013)**
Frequency of cleaning toilet			
3–7 days	29 (26.9)	1	1
After 7 days	15 (13.9)	0.401 (0.163–0.987)*	2.0 (0.489–8.184)
Skin disease			
Bathing child regularly			
Yes	29 (26.9)	1	1
No	13 (12.0)	6.948 (2.084–23.168)*	3.336 (0.906–12.281)*
Cleanliness of the child			
Yes	12 (11.1)	1	1
No	30 (27.8)	7.206 (3.027–17.157)**	5.444 (2.186–13.544)**
Tooth decay			
Brush teeth regularly			
Yes	15 (13.9)	1	
No	9 (8.3)	0.181 (0.022–1.456)	
Has not started yet	1 (0.9)	0.026 (0.003–0.260)*	

*$p < 0.05$.
**$p < 0.01$.

was reported that a child who did not have a bath regularly was 6.948 times more likely (2.084, 23.168; 95% CI) to have skin disease than the child who had a bath regularly. The cleanliness of the child was also found to be associated with skin diseases (0.139 (0.058–0.330); 95% CI). There was also a relationship between brushing teeth regularly and child tooth decay.

DISCUSSION

The study aimed to determine the relationship between the anthropometric status of the under-five children with household sanitation practice (WASH) in the rural areas Noakhali, Bangladesh. The study found out that more than half of the children deviated from good nutritional status.

Mother's education, hand washing, hygiene, and sanitation status were significantly associated with the children's nutritional status.

The findings showed that the prevalence of stunting, underweight, and wasting were about 46, 51.9, and 28.7%, respectively, which was somewhat lower than the study conducted in Afghanistan (To *et al.* 2016). A community-based cross-sectional study conducted in rural kebeles of Hidabu Abote District, North Shewa, Oromia Regional State, also reported that the prevalence of stunting, underweight, and wasting were 47.6, 30.9 and 16.8%, respectively, though stunting was quite similar to our study but the other two were lower than our study (Mengistu *et al.* 2013). Furthermore, this study's finding showed that the prevalence of stunting was higher as compared with a cross-sectional study conducted in Gumbrit, which reported a prevalence of 34% stunting, in Nigeria with 39.2% prevalence of wasting, and in Gambia with 31.2% prevalence of stunting (Akmatov 2011).

The education of parents was found to be an important factor that affects the nutritional status of their children, though our study did not find any significant relation, different studies from different countries determined the association between the education of parents and the nutritional status of under-five children (Mshida *et al.* 2018; van Cooten *et al.* 2019). Family income was also one of the variables found to be related to Height for Age Z score (HAZ) ($p = 0.003$) and it was an onward trend that showed a better nutritional status with the increase of family income.

Poor WASH practices have been reported to contribute to diarrhea-associated infections, which contribute to 50% of undernutrition among under-five children globally (Tarnoff 2015). Findings from this study showed that children who had diarrhea-associated infections for the past week before the survey date had a risk of being underweight, stunted and wasted (16.7% of undernutrition, 19.4% stunted and 11.1% wasted, respectively) among under-five children compared with those who had not diarrhea before the survey date.

Some hygiene practices which are related to the occurrence of diarrhea, such as toilet type, cleanliness of the toilet, frequency of cleaning toilets, using sandals during going to the toilet and materials used after, and among these practices handwash materials, availability of soap, toilet cleaning, and frequency of toilet cleaning were found to be associated with the occurrence of diarrhea and specifically cleaning of toilets was strongly associated with it. A study conducted in the Gaza strip also found a significant association between the occurrence of diarrhea and the cleaning of hands before and after eating, as well as after coming from the toilet (Abuzerr *et al.* 2020). In general, several studies that were carried out in developing communities suggest an association between childhood diarrhea and poor hygiene WASH conditions (Uwizeye *et al.* 2014; Hongxing *et al.* 2016; Kalakheti *et al.* 2016; Adane *et al.* 2017). Hence, future investigations that consider other WASH variables that were not included in this study are recommended.

Diarrhea tends to affect the absorption of nutrients by the body due to limited time spending on the food in the stomach which causes lowers appetite and whatever little food is taken is directed into recovery from the infection (Yudkin *et al.* 2009). Likewise, undernutrition may prolong the duration and frequency of diarrhea and worsen the overall health condition of the child (Ngure *et al.* 2014). Diarrhea may also have an indirect contribution to undernutrition through the costs of medication that households spend in treatment which may affect their food budget (Chase & Ngure 2016). Overall, water, hygiene and sanitation lead to diarrhea and finally, diarrhea leads to undernutrition.

STUDY LIMITATIONS

This study has some limitations, including study implementation in a small geographic area, insufficient data on dietary patterns of the local populations, and lack of ability to compare these data to the population outside this rural area. Besides, hygiene practices could have been over-reported, as it is common with all self-reported practices in personal interviews.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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