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# Childhood Malnutrition and the Association with Diarrhea, Water supply, Sanitation, and Hygiene Practices in Kersa and Omo Nada Districts of Jimma Zone, Ethiopia

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## ABSTRACT

**BACKGROUND:** Inadequate water supply, sanitation, hygiene practices, and diarrhea are related to malnutrition, but there is limited evidence in Ethiopia about their association. Thus, the objective of this study was to describe childhood malnutrition and the association with diarrhea, water supply, sanitation and hygiene practices.

**METHODS:** A case-control study design was performed from December 2018 to January 2019 in Kersa and Omo Nada districts of the Jimma Zone, Ethiopia. Both children aged 6 to 59 months were chosen randomly from malnourished and well-nourished children in 128 cases and 256 controls, respectively. Bodyweight, length/height, mid-upper arm circumference, and presence of edema of the children were measured according to the WHO references. Then, the nutritional status of the children was identified as a case or control using the cutoff points recommended by the WHO. To see the association-dependent and independent variables, logistic regression analysis was used.

**RESULTS:** A total of 378 children were included in this study (98.44%). Malnutrition was significantly increased among children who delayed breastfeeding initiation (AOR = 3.12; 95% CI: 1.62-6.00), had diarrhea (AOR = 9.22; 95% CI: 5.25-16.20), were living in households indexed as the poorest (AOR = 2.50; 95% CI: 1.12-5.62), defecated in a pit latrine without slab/open pit (AOR = 2.49; 95% CI: 1.17-5.30), collecting drinking water from less than/equal to 1 km distance (AOR = 4.77; 95% CI: 1.01-22.71) and sometimes practiced hand washing at the critical times (AOR = 2.58; 95% CI: 1.16-5.74) compared with their counterparts. However, lactating during the survey (AOR = 0.35; 95% CI: 0.18-0.67), water collection from unprotected sources (AOR = 0.22; 95% CI: 0.05-0.95) and collection and disposal of under-5 children feces elsewhere (AOR = 0.06; 95% CI: 0.01-0.49) significantly reduced the likelihood of malnutrition.

**CONCLUSIONS:** Early initiation of exclusive breastfeeding, diarrhea prevention, and the use of improved latrine and handwashing practices at critical times could be important variables to improve the nutritional status of children.

**KEYWORDS:** Child, diarrhea, hygiene, malnutrition, sanitation, water supply

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## Background

Malnutrition is a widely known nutritional disorder and one of the leading causes of morbidity and mortality among children in low-income countries.<sup>1-3</sup> It is one of the main health problems facing women and children in Ethiopia. The country has the second highest rate of malnutrition in Sub-Saharan Africa. According to the 2016 Ethiopia DHS report, 38%, 10%, and 24% of under-5 children were stunted, wasted, and underweight, respectively, and the problem is even worse in rural area.<sup>4</sup> Results from the 2019 Ethiopia mini DHS also showed that the prevalence of stunting, wasting, and underweight were 37%, 7%, and 21%, respectively.<sup>5</sup> Similarly, studies done in different parts of Ethiopia revealed that the magnitude of

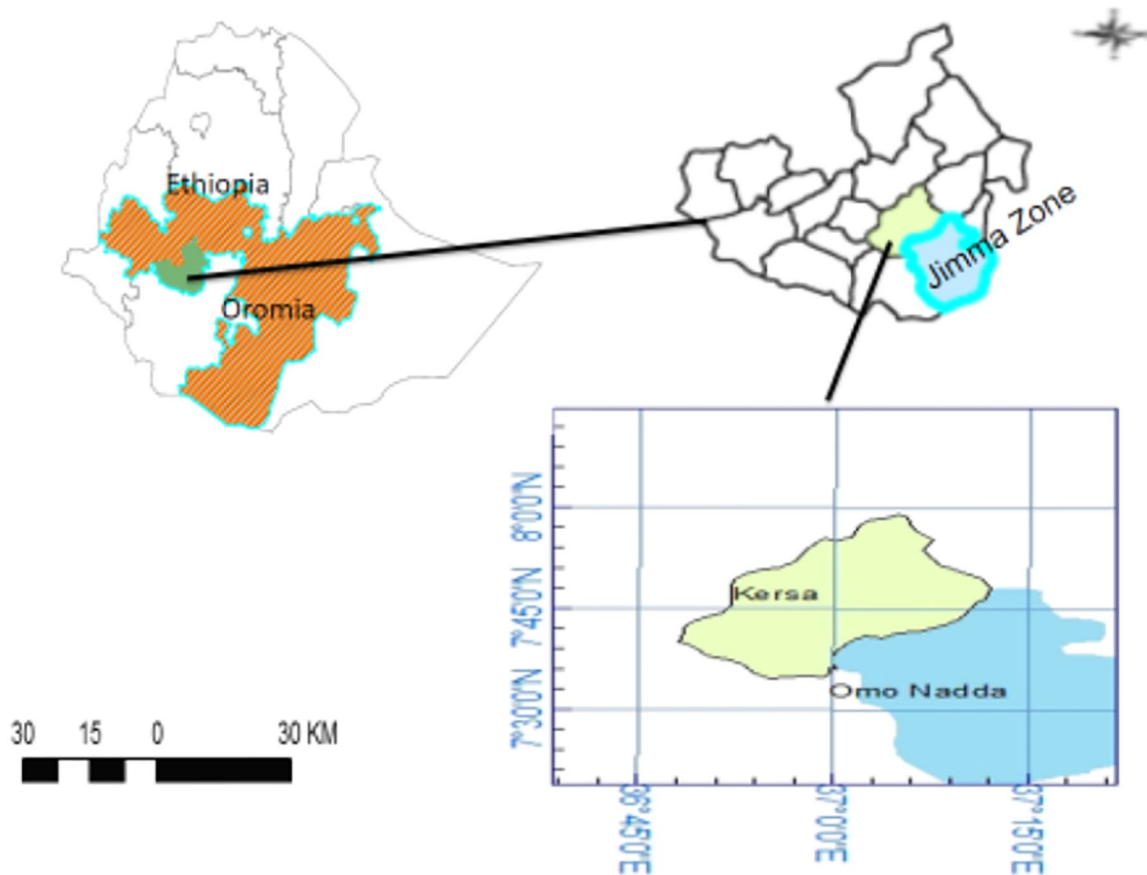
stunting, wasting, and underweight were high and the problem of malnutrition was a public health issue in Ethiopia.<sup>6-8</sup>

Poor water supply, sanitation, and hygiene (WASH) interventions create perfect conditions for the development of different infectious diseases that are linked to malnutrition.<sup>9,10</sup> These poor interventions can affect a child's nutritional status in at least 3 direct pathways: via diarrheal diseases, intestinal parasitic infections, and environmental enteropathy. It may indirectly impact the nutritional status of children by necessitating walking long distances in search of water and sanitation facilities and diverting a mother's time away from childcare.<sup>11</sup>

Children themselves may become affected by environmental contamination as they start crawling, walking, exploring,



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**Figure 1.** Map of the 2 selected study area from Jimma Zone, Ethiopia.

and putting objects in their mouths, which increases the risk of ingesting fecal bacteria from both human and animal sources. This leads to repeated bouts of diarrhea and intestinal worms, which in turn deteriorates the nutritional status of children.<sup>12,13</sup> The WASH benefit and Sanitation, Hygiene, Infant Nutrition Efficacy Project (SHINE) trial report showed that children who received WASH interventions still had high fecal exposure and there were typically ten times higher rates of enteric infection compared with children in high-income countries.<sup>14</sup> Moreover, recent study findings reported that there was little or no impact of selected WASH interventions on reducing childhood diarrhea and stunting.<sup>15-18</sup>

Previous studies have shown that socioeconomic factors, poor nutrition, and mothers' lack of awareness and manner of feeding led to an increase in the prevalence of malnutrition.<sup>2,19,20</sup> A meta-analysis of data from cluster-randomized controlled trials concluded that WASH interventions had a benefit on the improvement of nutritional status in under-5 children.<sup>21</sup> Specifically, studies done in different parts of Ethiopia showed that the presence of childhood diarrhea, safe disposal of children's feces, and the use of soap for handwashing were risk factors for childhood malnutrition.<sup>8,22,23</sup>

The available evidence revealed that the association between water supply, sanitation, and hygiene interventions and childhood malnutrition is limited in Ethiopia. Thus, the objectives of this study was to identify childhood malnutrition and the association with diarrhea, water, sanitation, and

hygiene practices in Kersa and Omo Nada districts of Jimma Zone, Ethiopia. The results of this study could help policy-makers, program planners, donors, and concerned bodies to prevent child malnutrition. It may also serve as a baseline for further studies of organizations working in this area.

## Methods and Materials

### *Study setting*

A case-control study was conducted in 2 purposively selected districts (Kersa and Omo Nadda) of the Jimma Zone, Oromia Regional State, Ethiopia, from December 2018 to January 2019. The Zonal capital, Jimma town, is located in southwest Ethiopia, 357 km away from Addis Ababa. Agriculture is the major economic activity and it includes mainly growing coffee and cattle rearing. According to the Jimma Zonal Health Office annual report (2019), the populations of Kersa and Omo Nadda were 227 959 and 208 517, respectively. About 81.65% of residents of the Kersa district and 71.7% residents of the Omo Nadda district rely on improved drinking water sources in 2018. Currently, the improved latrine coverage of the district is 40% for Kersa and 39% for Omo Nadda<sup>24</sup> (Figure 1).

### *Sample size and sampling*

The sample size was determined using a formula for calculating the double population proportion by assuming estimates of the proportion of well-nourished children ( $P_2$ ) as

43.8% (taking water sources as a major factor<sup>25</sup>),  $\alpha=1.96$  at 95% confidence level, odds ratio 1.89; (from literature, children living in households that had been using unprotected water sources were 1.89 times more likely to be acutely malnourished than those who had been using protected water sources<sup>26</sup>), power: 80% (0.84), the ratio of cases to controls was 1:2. This implies that 117 cases and 234 controls were required. After adding 10% for the nonresponse rate, the final samples were 128 for cases and 256 for controls.

Five health centers, which have centers for the treatment of undernourished children, were selected purposively from the 2 districts. Then, 3 kebeles (the smallest administrative unit) were selected from each district based on the level of malnutrition reported as high, medium, and low kebeles. Census was conducted to identify the number of under-5 children and their nutritional status in the kebeles. Then, the cases were randomly selected from the malnourished children and controls were randomly selected from well-nourished children.

All children from 6 to 59 months, living in Kersa and Omo Nada districts with Z-scores of weight-for-height (wasting)  $<-2$  (SD), weight-for-age (underweight)  $<-2$  SD, height-for-age (stunting)  $<-2$  SD, mid-upper arm circumference (MUAC) less than 11.5 cm or have edema based on growth reference of WHO<sup>27</sup> were the samples of cases, whereas children who are not fall under previous criteria were categorised as controls.

All children aged 6 to 59 months whose mothers lived for at least 1 year in the study district who were malnourished (cases) and well-nourished (control) were included in the study. Children whose mothers were seriously ill and could not communicate information were excluded from the study.

### Data collection

Bodyweight, length/height, mid-upper arm circumference, and presence of edema of the children were measured based on the WHO reference.<sup>27</sup> The weight and height of the children were measured using the Salter scale and measuring board, respectively. The body weight of all children was measured without shoes to the nearest 0.1g, whereas the height/length of children was measured to the nearest 0.1 cm. Each measurement was done twice, and the mean of the 2 readings was recorded. The weighing scale was calibrated regularly to a known weight. The ace scales' indicator was checked against zero reading after weighing every child. To convert raw anthropometric data (weight, height, and age of children) into an anthropometric Z-score (weight-for-age, height-for-age, and weight-for-height), the emergency nutrition assessment (ENA) for standardized monitoring and assessment of relief and transition (SMART) was used. Thumb pressure was applied to the upper side of both feet for 3 seconds to diagnose the presence of edema. The presence was diagnosed if a bilateral depression (pitting) remained after the press release. Mid-upper arm circumference was measured in centimeters using MUAC tape on the left arm and was recorded to the nearest 0.1 cm. The nutritional status of children was identified as case or control using

cutoff points recommended by the World Health Organization based on the Z-score, edema, and MUAC values.<sup>27</sup> Confirmed malnourished children were linked to the health center after consultation with the data collector. Nursing professionals undertook all these anthropometric measurements.

Then after data were collected by interviewing mothers/caretakers of the children using a pretested questionnaire. The questionnaire was adapted from the WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation, and Hygiene 2017, core questions on water, sanitation, and hygiene for the household survey.<sup>28</sup> Some questions were revised to suit the context of the study by the principal investigator.

The questionnaire consisted of variables related to socio-demographics, children, water supply, sanitation, and hygiene practices. The wealth index was developed from assets and other housing characteristics using principal component analysis.<sup>29</sup> Handwashing at critical times was assessed through information about their handwashing behavior after defecation, before handling food/water, before feeding a child, or after cleaning the child stool. If they responded in the affirmative about these critical times of handwashing, we gave the remark; always; if at least 1 was missed, we gave the remark; sometimes. Mothers/caregivers were asked about the age of their children or this information was collected from the immunization cards if present. If they did not know the age or did not have immunization cards, data collectors asked them whether the child was born before or after known holidays and/or local market days. They were also asked about any occurrence of diarrhea and vaccination status based on the age of the child to identify the past 2 weeks of diarrhea and vaccination of children.

Through face-to-face interviews with mothers/caregivers, professional nurses who undertook anthropometric measurements collected the survey data. The questionnaire used for this data collection was originally prepared in English and then translated into the local language (Afan Oromo) and back retranslated into English to check its consistency by public health and linguistics professionals. Then, the necessary correction and modification of the instrument were made.

The mother's interview and anthropometric measurements were done by data collectors following 2 days of intensive training, which included orientation, demonstration, and field procedures. Pretest of the instrument and the procedure was conducted with 5% of mothers or caregivers of the children in the selected households before actual data collection. Anthropometric measurements were done by using calibrated and pretested scales. The overall day-to-day data collection process and completeness of the collected questionnaires; it was checked and any other amendments were made by supervisors and the principal investigator.

### Data analysis

Data were entered, cleaned, and checked for correctness using EpiData version 4.2. After exportation, all statistical analyses were carried out using SPSS version 24. Data were described by

frequency, percentage, and mean (for continuous data) to compare the cases and controls. It was categorized as poor, middle, or rich. The logistic regression model was used to assess whether water supply, sanitation, and hygiene practices are associated with childhood malnutrition. The crude odds ratio (COR) and 95% CI were used to identify the unadjusted strength of association between independent and dependent variables in bivariate analysis. To adjust for confounders, multivariable analysis was used. All variables that had a *P*-value of .25 or less in the bivariate analysis were included in the multivariable analysis after multicollinearity among variables was assessed by calculating the variance inflation factor (VIF). Adjusted odds ratios (AOR) with 95% CI were computed to assess the strength of the association and a *P*-value <.05 was used to declare statistical significance in the multivariable analysis.

## Results

### *Study population characteristics*

A total of 378 children (126 cases and 252 controls) were included in this study, with a response rate of 98.44%. The mean age of these children was 31.2 (SD ± 8.5) months in cases and 30.1(±12.2) months in controls. Seventy-three percent of cases and 23% of control children had diarrhea at least once in the past 2 weeks during the visit. The mean age of the mothers was 28.6 (±3.1) years for cases and 28.1(±2.9) years for controls. Regarding the educational status of the mothers, 44% of cases and 38.9% of controls had no or lacked formal education. In this study, 30.16% of cases and 35.32% of controls belonged to the poor wealth index, whereas 31.75% of cases and 34.13% of controls were from good wealth status, respectively (Table 1).

The main sources of drinking water in households in 96.8% of cases and 92.5% of controls were from protected sources. The mean daily water consumption of study participants was 16.2(±27.8) liters per capita per day for cases and 14.9 (±11.2) liters per capita per day for controls. The mean time to fetch water was 45.2(±16.8) minutes for cases and 39.7(±19.5) minutes for controls. In addition, the approximate distances of drinking water sources from the home of both populations were almost less than 1 km. Sixty-three percent of the case respondents and 75.8% of the control respondents reported that the amount of water collected for domestic purposes was insufficient for their families. Seventy-six percent of cases and 84.8% of controls further explained that the main reason for the inability to access sufficient quantities of water when needed was the unavailability of water in the source. In the home of 91.3% of cases and 93.7% of controls, there were no water treatment practices at the point of use (Table 2).

Eighty-one percent of households of cases and 75.4 % of households of controls used pit latrines with the slab/superstructure for defecation. Almost all of these latrines were not shared with other households in both cases and controls. Concerning places where under 5 children usually go to

defecate, 49.2% cases and 46.4% control children's defecated in the open field. Among the total households interviewed in this study, 42.9% of households in cases and 64.3% of households in the control disposed of their domestic solid waste by burning. Nineteen percent of cases and 9% of controls did not wash their hands at critical times (Table 3).

### *Risk factors for childhood malnutrition*

As shown in Table 4, number of under-5 children in the households, educational status of the mother/caregiver of the child, initiation of breastfeeding, child breastfeed, the presence of diarrhea, wealth index, the main source of drinking-water, the main source of water used by households for cooking and washing, the distance of drinking water sources, time being taken to get water, the amount of water they get, kind of drinking water storage containers, cleaning of drinking water storage containers, place of defecation, the usual defecation site of under 5 children, feces disposal sites for under 5 children, domestic waste disposal sites, and handwashing at critical times were significant predictors of childhood malnutrition at *P*<.25. Of these predictor variables only initiation of breastfeeding, child breastfeed, the presence of diarrhea, the distance of drinking water sources, place of defecation, feces disposal sites for under 5 children, and hand washing at the critical time were found to be independent predictors of childhood malnutrition in the bivariate and multivariate analysis.

There was also a negative association between malnutrition and using unprotected water sources for drinking (AOR = 0.22; 95% CI: 0.05-0.95). The odds of malnutrition were increased by 2.12 among children who had delayed initiation of breastfeeding compared to those who started early breastfeeding and were entirely dependent on it (AOR = 3.12; 95% CI: 1.62-6.00). Similarly, odds of having malnutrition was 9.22 times more likely increased in children who had diarrhea at least once in the past 2 weeks compared with those who did not have diarrhea (AOR = 9.22; 95% CI: 5.25-16.20). Families who collected drinking water from a distance of less than/equal to 1 km were 4.77 times more likely to have malnourished children compared to those who collected from a distance of greater than 1 km (AOR = 4.77; 95% CI: 1.01-22.71). Children living with households who collected and disposed of child feces elsewhere were 94% less likely to have malnutrition than those children living with households collected and disposed of in the latrine (AOR = 0.06; 95% CI: 0.01-0.49). For defecation purposes, households who used pit latrine without slab/open pit were found to have more malnourished children than those that used pit latrine with slab (AOR = 2.45; 95% CI: 1.20-5.00). The odds of having childhood malnutrition were 2.58 times higher among children living with mothers who wash their hands sometimes at critical times (AOR = 2.58; 95% CI: 1.16-5.74) compared to those who wash always (Table 4).

**Table 1.** Socio-demographic characteristics of study participants of Kersa and Omo Nada districts in Jimma Zone, Ethiopia.

VARIABLE	SUBGROUP	CASE	CONTROL
		NUMBER (%)	NUMBER (%)
Age of mother	19-25	31 (24.6)	70 (27.8)
	26-31	75 (59.5)	151 (59.9)
	32-39	20 (15.9)	31 (12.3)
Family size	≤5	43 (34.1)	88 (34.9)
	>5	83 (65.9)	164 (65.1)
Number of under-5 children in the households	1	77 (61.1)	169 (67.1)
	2	49 (38.9)	83 (32.9)
Educational status of the mother/caregiver of the child	No/lack of formal education	56 (44.4)	98 (38.9)
	Literate	70 (55.6)	154 (61.1)
Sex of the child	Female	48 (38.1)	107 (42.5)
	Male	78 (61.9)	145 (57.5)
Initiation of breastfeeding	Delayed (>1 h of birth)	53 (42.1)	41 (16.3)
	Early (within 1 h of birth)	73 (57.9)	211 (83.7)
Child breastfeed (mo)	Up to 24	92 (73.0)	131 (52.0)
	Still now	22 (17.5)	95 (37.7)
	Others	12 (9.5)	26 (10.3)
Age of first introduce liquids or foods to the baby (mo)	Below 6	9 (7.1)	5 (2.0)
	6	117 (92.9)	247 (98.0)
Livestock ownership	Yes	16 (12.7)	40 (15.9)
	No	110 (87.3)	212 (84.1)
Had diarrhea at least once in the past 2 wk(s)	Yes	92 (73.0)	58 (23.0)
	No	34 (27.0)	194 (77.0)
Wealth index	Poor	38 (30.16)	89 (35.32)
	Medium	48 (38.10)	77 (30.56)
	Wealthiest	40 (31.75)	86 (34.13)

## Discussion

Many factors affect the nutritional status of children in a low-income country like Ethiopia. The objectives of the present study was to identify childhood malnutrition and the association with diarrhea, water, sanitation and hygiene practices in Kersa and Omo Nada districts of Jimma Zone, Ethiopia. In this study, we found evidence that the risks of childhood malnutrition were significantly reduced among mothers/caregivers whose children were breast-feeding during the survey, who were collecting water from unprotected sources and were properly disposing of children's feces elsewhere. However, delayed initiation of breast-feeding, the presence of diarrhea, poor living conditions (indexed as poor), living with families who defecated in pit latrines without a slab or in open pits, collecting drinking water from a

distance of less than/equal to 1 km and lack of handwashing practices at a critical time significantly increased the likelihood of childhood malnutrition.

Consistent with previous studies conducted in Malaysia and Bangladesh,<sup>20,30</sup> our study showed a strong association between childhood malnutrition and wealth status. In the poorest households, mothers might have inadequate access to socio-economic resources to meet the nutritional needs of their children.<sup>31</sup>

Severe and persistent diarrhea episodes cause malnutrition in individual patients; malnourished children, on the other side, are more likely to experience diarrhea complications.<sup>32</sup> Malnutrition leads to increased diarrheal disease frequencies and durations, accounting for a doubling of the diarrhea burden (days of diarrhea) in malnourished children.<sup>33</sup> In a related

**Table 2.** Drinking water supply related characteristics of study participants of Kersa and Omo Nada districts in Jimma Zone, Ethiopia.

VARIABLE	SUBGROUP	CASE	CONTROLS
		NUMBER (%)	NUMBER (%)
The main source of drinking-water	Protected sources	122 (96.8)	223 (92.5)
	Unprotected sources	4 (3.2)	19 (7.5)
The main source of water used by households for cooking and washing	Protected sources	115 (91.3)	214 (84.9)
	Unprotected sources	11 (8.7)	38 (15.1)
The distance of drinking water sources (Km)	≤1	123 (97.6)	232 (92.1)
	>1	3 (2.4)	20 (7.9)
Time to take to go there, get water, and come back (min)	≤30	50 (39.7)	130 (51.6)
	>30	76 (60.3)	122 (48.4)
Amount of water get sufficient	Sufficient	47 (37.3)	61 (24.2)
	Not sufficient	79 (62.7)	191 (75.8)
The main reason for unable to access sufficient quantities of water when needed	Water not available from the source	60 (75.9)	162 (84.8)
	Water too expensive	5 (6.3)	4 (2.1)
	Source not accessible	14 (17.7)	25 (13.1)
Kind of drinking water storage containers	Narrow-mouthed	122 (96.8)	249 (98.8)
	Both narrow and wide-mouthed	4 (3.2)	3 (1.2)
Cleaning of drinking water storage container	Daily	54 (42.9)	73 (29.0)
	Several times per week	17 (13.5)	17 (6.7)
	Once a week	55 (43.7)	162 (64.3)
Household-level drinking water treatment	Treat	11 (8.7)	16 (6.3)
	Not treat	115 (91.3)	236 (93.7)

way, in this study, diarrhea among children was shown to be a significant predictor of childhood malnutrition. Our findings revealed that the presence of the preceding 2 weeks of childhood diarrhea and malnutrition were positively associated. This finding was consistent with a previous finding that showed that the presence of childhood diarrhea increased the risk of malnutrition.<sup>6,8</sup>

Collecting water from a distance of less than/equal to 1km source was found to be a strong predictor of childhood malnutrition in this study. The nearest sources used in this analysis could be unregulated water sources that expose them to fecal bacteria and intestinal worms, which in turn deteriorates the nutritional condition of children due to malabsorption. The findings were supported by other studies done in rural Ethiopia and Kenya.<sup>34,35</sup>

This analysis showed that there was an inverse association between household access to a improved toilet facility and childhood malnutrition. Our findings incline to confirm the results of other studies carried out in Ethiopia and other parts of the world.<sup>20,34,36</sup> Improper disposal of waste causes environmental contamination that can affect a child's nutritional

status via environmental enteric dysfunction (enteropathy). This might happen when children are repeatedly exposed to pathogenic bacteria that prevent the absorption of nutrients by damaging the intestinal mucosa.<sup>11</sup> The findings of our study agreed with the pooled evidence of a systematic review done on environmental risk factors associated with child stunting by Vilcins et al.<sup>37</sup>

Regular hand washing at critical times was negatively associated with childhood malnutrition, which was in line with studies conducted in Bangladesh and Armenia, which revealed a significant inverse association between handwashing at critical times and childhood malnutrition.<sup>17,38</sup> Another cluster randomized controlled trial study done in Pakistan proved that handwashing promotion can improve the nutritional status of children.<sup>17,38,39</sup>

This study has some limitations. Variables such as data related to the nutrition and health status of mothers, the food security of households, and the type of diet children consumed that influenced the nutritional status of children were not fully assessed in the present study. As the drinking water sources,

**Table 3.** Sanitation and hygiene practices of study participants of Kersa and Omo Nada districts in Jimma Zone, Ethiopia.

VARIABLE	SUBGROUP	CASE	CONTROL
		NUMBER (%)	NUMBER (%)
Place of defecation	Pit latrine with slab	102 (81.0)	190 (75.4)
	Pit latrine without slab/open pit	24 (19.0)	62 (24.6)
Share the facility with another household	Yes	1 (0.8)	9 (3.6)
	No	125 (99.2)	243 (96.4)
Do all household members use the latrine?	Yes always	122 (96.8)	247 (98.0)
	Yes sometime	4 (3.2)	5 (2.0)
Access and use of latrine at all times of the day and night by household members	Yes	107 (84.9)	213 (84.5)
	No	19 (15.1)	39 (15.5)
The main reason why household members were unable to access and use the latrine at all times of the day and night	Unable to use the toilet	5 (26.3)	6 (15.4)
	Others	14 (73.7)	33 (84.6)
A place where under 5 children usually go to defecate	Household/public latrine	13 (10.3)	51 (20.2)
	Open defecation	62 (49.2)	117 (46.4)
	Others	51 (40.5)	84 (33.3)
If there are children under 5 who didn't use the latrine what is done with their feces?	Collected and disposed of in the latrine	125 (99.2)	228 (90.5)
	Collected and disposed of elsewhere	1 (0.8)	24 (9.5)
Households domestic waste disposal place	Household waste pit	45 (35.7)	60 (23.8)
	Open area	27 (21.4)	30 (11.9)
	Burned	54 (42.9)	162 (64.3)
Latrine most often used have handwashing facilities with soap	Yes, with soap and water	4 (3.2)	6 (2.4)
	Sometimes	44 (34.9)	57 (22.6)
	Take your soap and water		14 (5.6)
	No	78 (61.9)	175 (69.4)
Hand washing at the critical time	Yes, always	102 (81.0)	229 (90.9)
	Some times	24 (19.0)	23 (9.1)

sanitation utilization, hygienic practices at critical time and diarrhea occurrences were assessed according to the mothers/caregivers self-reporting without the confirmation of the experts, the study could be affected by social desirability bias. Another limitation was that, because mothers/caregivers were also questioned about their children's number of diarrhea in the last 2 weeks, there might be a recall bias.

## Conclusions

The findings of this study confirmed that the odds of having malnutrition were significantly reduced among mothers/caregivers whose children were breast-feeding during the survey, who were collecting water from unprotected sources and were properly disposing of children's feces elsewhere. On the

contrary, it was significantly increased among children who delayed breastfeeding initiation, had diarrhea, were living in households indexed as the poorest, defecated in a pit latrine without slab/open pit, collecting drinking water from less than/equal to 1 km distance and sometimes practiced hand washing at the critical times. Therefore, the current study suggests that promoting the early initiation of exclusive breastfeeding, preventing diarrhea, the use of improved latrines, and handwashing at critical times are needed to improve the nutritional status of children. Additionally, WASH programmers and other NGOs working on child health should emphasize integrating nutrition with sanitation and hygiene programs to create awareness and induce communities' behavior change.



**Table 4.** Bivariate and multivariable analysis of childhood malnutrition and the association with diarrhea, water supply, sanitation, and hygiene practices in Kersa and Omo Nada districts of Jimma Zone, Ethiopia.

VARIABLE	SUBGROUP	CASE NUMBER (%)	CONTROL NUMBER (%)	CRUDE OR (95% CI)	ADJUSTED OR (95% CI)
Number of under-5 children in the households	1	77 (61.1)	169 (67.1)	1	
	2	49 (38.9)	83 (32.9)	1.30 (0.83-2.02)	
Educational status of the mother/caregiver of the child	No/lack of formal education	56 (44.4)	98 (38.9)	1.25 (0.82-1.94)	
	Literate	70 (55.6)	154 (61.1)	1	
Initiation of breastfeeding	Delayed (>1 h of birth)	53 (42.1)	41 (16.3)	3.73 (2.29-6.08)*	3.12 (1.62-6.00)*
	Early (within 1 h of birth)	73 (57.9)	211 (83.7)	1	1
Child breastfeed (mo)	Up to 24	92 (73.0)	131 (52.0)	1	1
	Still now	22 (17.5)	95 (37.7)	0.33 (0.19-0.56)*	0.35 (0.18-0.67)*
	Others (<24)	12 (9.5)	26 (10.3)	0.66 (0.62-1.37)	0.56 (0.22-1.39)
Had diarrhea at least once in the past 2 wk(s)	Yes	92 (73.0)	58 (23.0)	9.05 (5.54-14.78)*	9.22 (5.25-16.20)*
	No	34 (27.0)	194 (77.0)	1	1
Wealth index	Poor	38 (30.16)	89 (35.32)	0.92 (0.54-1.57)	2.50 (1.12-5.62)*
	Medium	48 (38.10)	77 (30.56)	1.34 (0.80-2.25)	1.62 (0.78-3.39)
	Wealthiest	40 (31.75)	86 (34.13)	1	1
The main source of drinking-water	Protected sources	122 (96.8)	223 (92.5)	1	1
	Unprotected sources	4 (3.2)	19 (7.5)	0.40 (0.13-1.21)	0.22 (0.05-0.95)*
The main source of water used by households for cooking and washing	Protected sources	115 (91.3)	214 (84.9)	1	
	Unprotected sources	11 (8.7)	38 (15.1)	0.54 (0.67-1.09)	
The distance of drinking water sources (Km)	≤1	123 (97.6)	232 (92.1)	5.53 (1.03-12.13)*	4.77 (1.01-22.71)*
	>1	3 (2.4)	20 (7.9)	1	1
Time to take to go there, get water, and come back (min)	≤30	50 (39.7)	130 (51.6)	1	
	>30	76 (60.3)	122 (48.4)	1.62 (1.05-2.50)*	
Amount of water get sufficient	Sufficient	47 (37.3)	61 (24.2)	1	
	Not sufficient	79 (62.7)	191 (75.8)	0.54 (0.54-0.85)*	
Kind of drinking water storage containers	Narrow-mouthed	122 (96.8)	249 (98.8)	0.37 (0.08-1.67)	
	Both narrow and wide mouthed	4 (3.2)	3 (1.2)	1	
Cleaning of drinking water storage container	Daily	54 (42.9)	73 (29.0)	1	
	Several times per week	17 (13.5)	17 (6.7)	1.35 (0.63-2.89)	
	Once a week	55 (43.7)	162 (64.3)	0.46 (0.29-0.73)*	
Place of defecation	Pit latrine with slab	69 (54.8)	188 (74.6)	1	1
	Pit latrine without slab/open pit	57 (45.2)	64 (25.4)	2.43 (1.55-3.81)*	2.45 (1.20-5.00)*
A place where under 5 children usually go to defecate	Use latrine	13 (10.3)	51 (20.2)	1	
	Open defecation	62 (49.2)	117 (46.4)	2.28 (1.04-4.99)*	
	Other	51 (40.5)	84 (33.3)	2.54 (1.13-5.69)*	
If there are children under 5 who didn't use the latrine what is done with their feces?	Collected and disposed of in the latrine	125 (99.2)	228 (90.5)	1	1
	Collected and disposed of elsewhere	1 (0.8)	24 (9.5)	0.08 (0.01-0.57)*	0.06 (0.01-0.49)*
Households domestic waste disposal place	Household waste pit	45 (35.7)	60 (23.8)	1	
	Open area	27 (21.4)	30 (11.9)	1.20 (0.63-2.29)	
	Burned	54 (42.9)	162 (64.3)	0.44 (0.27-0.73)*	
Hand washing at the critical time	Yes, always	102 (81.0)	229 (90.9)	1	1
	Some times	24 (19.0)	23 (9.1)	2.34 (1.26-4.34)*	2.58 (1.16-5.74)*

\*P &lt; .05.

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## Author's Contributions

NES participated in the design of the study, conducted the statistical analysis, interpretation of data, and drafted and revised the manuscript. ABH, BMA, and SRG participated in the design of the study and critical review of the manuscript. All authors read and approved the final manuscript.

## Ethical Considerations

The study was reviewed and ethical clearance was secured from Addis Ababa University, Ethiopian Institute of Water Resources. Because of the high proportion of illiteracy to read the consent form, informed verbal consent was obtained from mothers/caregivers after explaining the purpose of the study. Mothers/caregivers were assured of confidentiality concerning all information acquired. Children who were found with childhood malnutrition during visits, and those who did not start treatment, were linked to the health center after consultation.

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## Data Availability

Data and materials from this study can be obtained from the corresponding author on reasonable request.

## REFERENCES

- Müller O, Krawinkel M. Malnutrition and health in developing countries. *CMAJ*. 2005;173:279-286.
- Musa TH, Musa HH, Ali EA, Musa NE. Prevalence of malnutrition among children under five years old in Khartoum State, Sudan. *Polish Ann Med*. 2014;21:1-7.
- Daboné C, Delisle HF, Receveur O. Poor nutritional status of schoolchildren in urban and peri-urban areas of Ouagadougou (Burkina Faso). *Nutr J*. 2011;10:34.
- Central Statistical Agency/CSA/Ethiopia and ICF. *Ethiopia Demographic and Health Survey 2016*. CSA and ICF; 2016.
- Ethiopian Public Health Institute (EPHI) (Ethiopia) and ICF. *Ethiopia Mini Demographic and Health Survey 2019: Key Indicators*. EPHI and ICF; 2019.
- Amare D, Negesse A, Tsegaye B, Assefa B, Ayenib B. Prevalence of undernutrition and its associated factors among children below five years of age in Bure Town, West Gojjam Zone, Amhara National Regional State, Northwest Ethiopia. *Adv Public Health*. 2016;18:1-8.
- Gelano TF, Birhan N, Mekonnen M. Prevalence of undernutrition and its associated factors among under-five children in Gondar city, Northwest Ethiopia 2014. *J Harmon Res Med Health Sci*. 2015;2:163-174.
- Fekadu Y, Mesfin A, Haile D, Stoecker BJ. Factors associated with nutritional status of infants and young children in Somali Region, Ethiopia: a cross-sectional study. *BMC Public Health*. 2015;18:1-9.
- UNICEF. The role of water, sanitation & hygiene in the fight against child undernutrition. 2015. Accessed May 29, 2019. [http://www.susana.org/\\_resources/documents/default/3-2385-7-1450185216.pdf](http://www.susana.org/_resources/documents/default/3-2385-7-1450185216.pdf)
- Ziegelbauer K, Speich B, Mäusezahl D, Bos R, Keiser J, Utzinger J. Effect of sanitation on soil-transmitted helminth infection: systematic review and meta-analysis. *PLoS Med*. 2012;9:1-17.
- Fenn B, Bulti AT, Nduna T, Duffield A, Watson F. An evaluation of an operations research project to reduce childhood stunting in a food-insecure area in Ethiopia. *Public Health Nutr*. 2012;15:1746-1754.
- RahJH, Cronin AA, Badgaiyan B, Aguayo VM, Coates S, Ahmed S. Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. *BMJ Open*. 2015;5:e005180. doi:10.1136/bmjopen-2014-005180.
- Humphrey JH. Child undernutrition, tropical enteropathy, toilets, and hand-washing. *Lancet (Lond, Engl)*. 2009;374:1032-1035.
- Pickering AJ, Null C, Winch PJ, et al. The WASH benefits and SHINE trials: interpretation of WASH intervention effects on linear growth and diarrhoea. *Lancet Glob Health*. 2019;7:e1139-e1146.
- Null C, Stewart CP, Pickering AJ, et al. Effects of water quality, sanitation, hand-washing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. *Lancet Glob Health*. 2018;6:e316-e329.
- Pickering AJ, Njenga SM, Steinbaum L, et al. Effects of single and integrated water, sanitation, handwashing, and nutrition interventions on child soil-transmitted helminth and Giardia infections: a cluster-randomized controlled trial in rural Kenya. *PLoS Med*. 2019;16:1-21.
- Luby SP, Rahman M, Arnold BF, et al. Effects of water quality, sanitation, hand-washing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster-randomised controlled trial. *Lancet Glob Health*. 2018;6:e302-e315.
- Humphrey JH, Mbuya MNN, Ntozini R, et al. Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe: a cluster-randomised trial. *Lancet Glob Health*. 2019;7:e132-e147.
- Amsalu S, Tigabu Z. Risk factors for severe acute malnutrition in children under the age of five: a case-control study. *Ethiop J Health Dev*. 2008;22:21-25.
- Wong HJ, Moy FM, Nair S. Risk factors of malnutrition among preschool children in Terengganu, Malaysia: a case control study. *BMC Public Health*. 2014;14:1-10.
- Dangour AD, Watson L, Cumming O, et al. Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. *Cochrane Database Syst Rev*. 2013;8:CD009382.
- Fentahun W, Wubshet M, Tariku A. Undernutrition and associated factors among children aged 6-59 months in East Belesa District, northwest Ethiopia: a community based cross-sectional study. *BMC Public Health*. 2016;16:1-10.
- Darsene H, Geleto A, Gebeyehu A, Meseret S. Magnitude and predictors of undernutrition among children aged six to fifty nine months in Ethiopia: a cross sectional study. *Arch Public Health*. 2017;75:1-11.
- Jimma Zonal Health Office. *Disease Prevention and Control Department Annual Report*. Jimma Zonal Health Office; 2019.
- Bantamen G, Belaynew W, Dube J. Assessment of factors associated with malnutrition among under five years age children at Machakel Woreda, northwest Ethiopia: a case control study. *J Nutr Food Sci*. 2014;4:1-7.
- Frozanfar MK, Yoshida Y, Yamamoto E, et al. Acute malnutrition among under-five children in Faryab, Afghanistan: prevalence and causes. *Nagoya J Med Sci*. 2016;78:41-53.
- World Health Organization. WHO child growth standards. *World Health Organ*. 2006;80:1-312.
- WHO/UNICEF. *Core Questions on Drinking Water and Sanitation for Household Surveys*. WHO/UNICEF; 2006.
- Fry K, Firestone R, Chakraborty NM. *Measuring Equity with Nationally Representative Wealth Quintiles*. Washington DC: Popul. Serv. Int.; 2014.
- Ahsan KZ, Arifeen S, El Al-Mamun MA, Khan SH, Chakraborty N. Effects of individual, household and community characteristics on child nutritional status in the slums of urban Bangladesh. *Arch Public Health*. 2017;75:1-13.
- Daniel D, Diener A, Pande S, et al. Understanding the effect of socio-economic characteristics and psychosocial factors on household water treatment practices in rural Nepal using Bayesian Belief Networks. *Int J Hyg Environ Health*. 2019;222:847-855.
- Nel ED. Diarrhoea and malnutrition. *S Afr J Clin Nutr*. 2010;23:15-18.
- Guerrant RL, Schorling JB, McAuliffe JF, De Souza MA. Diarrhea as a cause and an effect of malnutrition: diarrhea prevents catch-up growth and malnutrition increases diarrhea frequency and duration. *Am J Trop Med Hyg*. 1992;47:28-35.
- van Cooten MH, Bilal SM, Gebremedhin S, Spigt M. The association between acute malnutrition and water, sanitation, and hygiene among children aged 6-59 months in rural Ethiopia. *Matern Child Nutr*. 2019;15:1-8.
- Nygren BL, Reilly CEO, Rajasingham A, et al. The relationship between distance to water source and moderate-to-severe diarrhea in the global enterics multi-center study in Kenya, 2008-2011. *Am J Trop Med Hyg*. 2016;94:1143-1149.
- Masibo PK, Makoka D. Trends and determinants of undernutrition among young Kenyan children: Kenya Demographic and Health Survey; 1993, 1998, 2003 and 2008-2009. *Public Health Nutr*. 2012;15:1715-1727.
- Vilcins D, Sly PD, Jagals P. Environmental risk factors associated with child stunting: a systematic review of the literature. *Ann Glob Health*. 2018;84:551.
- Demirchyan A, Petrosyan V. Hand hygiene predicts stunting among rural children in Armenia. *Eur J Public Health*. 2019;27:502-503.
- Bowen A, Agboatwalla M, Luby S, Tobery T, Ayers T, Hoekstra RM. Association between intensive handwashing promotion and child development in Karachi, Pakistan. *Arch Pediatr Adolesc Med*. 2012;166:1037-1044.