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Journal of Water & Health

IWA PUBLISHING

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Journal of Water and Health Vol 19 No 6, 1030 doi: 10.2166/wh.2021.123

Examination of the Cameroon DHS data to investigate how water access and sanitation services are related to diarrhea and nutrition among infants and toddlers in rural households

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ABSTRACT

Undernutrition among children is a significant issue in rural areas in Cameroon, with diarrhea being one of the major contributing risk factors. To gain a better understanding of the risk factors of diarrhea, the main objective of this epidemiological study was to examine associations between water access and sanitation service with diarrhea, diet diversity, and anemia among infants and toddlers in rural households in Cameroon. The study involved household- and individual-level data of 2,129 rural-dwelling infants and toddlers from the Demographic and Health Survey database. About one-third of infants and toddlers were experiencing diarrhea, with higher odds among those who lived in households with limited water service ($p = 0.028$). The odds of having diarrhea were 50% higher among infants and toddlers when households did not have sanitation facilities ($p = 0.007$). The lack of improved water and sanitation was also associated with a low intake of various food groups among older infants and toddlers. The prevalence of anemia was high, but no significant differences were seen by water and sanitation services. The achievement of SDG #6 will help address undernutrition and achieve other SDGs, including improving health and wellbeing.

Key words: diarrhea, nutrition, rural, sanitation, water

HIGHLIGHTS

- Access to improved water is limited in rural areas, with surface water being a common source of drinking water.
- Diarrhea among a very young age group of infants and toddlers is also prevalent and is associated with water and sanitation services.
- The use of surface water for drinking at the household level is associated with diarrhea and also poor diversity in feeding a variety of foods to infants and children.

INTRODUCTION

Diarrhea, defined as the passage of three or more loose or liquid stools per day, is experienced among young children on average three times per year (WHO 2017). In developing countries, diarrheal disease is a leading cause of mortality and morbidity among young children (Troeger *et al.* 2018). Each episode of diarrhea deprives a child of vital nutrients that are critical for growth. Repeated diarrhea has an adverse synergistic effect, resulting in undernutrition, making children more vulnerable to diarrhea. The prevention of diarrhea is critical for optimal growth and development among children. Specifically, it has been shown that the control of diarrhea during infancy and toddlerhood is critical to prevent stunted and faltered linear growth later in life (Moore *et al.* 2001; Checkley *et al.* 2003; Brander *et al.* 2019). Infants and toddlers living in poor or remote communities are most at risk of diarrhea due to a lack of healthcare services and effective interventions.

To address undernutrition among children, attention has been drawn to preventive approaches that recognize the importance of a clean, safe environment to prevent cross-contamination and diarrheal infection. In a review examining the link between water, sanitation, and early child development, Ngure *et al.* (2014) proposed the importance of a clean environment

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to prevent the ingestion of microbes and pathogens by infants and young children. With the evidence on the importance of preventing cross-contamination, access to improved water, sanitation, and hygiene (WASH) has been endorsed as a key means of combating diarrhea and child morbidity and mortality in developing countries (WHO & UNICEF 2021). In alignment with it, three randomized trials, i.e., WASH Benefits Kenya, WASH Benefits Bangladesh, SHINE Zimbabwe, were undertaken to test improved household-level WASH with ready to use feeding supplements on growth and diarrhea rate among young children. In all the three trials, the WASH interventions had no additional effect on linear growth compared with feeding supplements (Cumming *et al.* 2019). Similarly, in the review of other small-scale WASH plus nutrition interventions, the modest level of reduction in the diarrhea rate was observed, but no significant joint effect was noted in children's growth. In this review, the complexity and interconnection among various WASH components and nutrition were recognized, and it was highlighted that improvement in the infrastructure at the community level is critical to see WASH-related health improvement at the household and individual levels (Nounkeu & Dharod 2021).

In fact, considering the complexity of WASH access and accurately measuring it, a joint WHO and UNICEF program has updated drinking water and sanitation classifications of improved versus unimproved water sources to more specific categories. For instance, for drinking water, this advanced measure takes into account not only the source of water, but also the time it takes one to reach the source. For instance, even if a household has access to an improved water source, this access is considered limited if it takes over 30 min per round-trip to collect water. Similarly, in case of access to a sanitation facility, if a facility is shared with other households, then access is considered limited rather than improved.

In low-income countries, rural areas experience a disproportionate burden of poor water access and sanitation services. Particularly in sub-Saharan Africa, a large gap remains between urban and rural areas in access to water and sanitation services (WHO & UNICEF 2021). In rural areas, households generally rely on surface water, involving walking long distances to obtain it, with the women or caretakers holding the main responsibility of fetching water for their households (Sinharoy & Caruso 2019). Studies in rural areas have shown that women spend an average of 3–4 hours per day fetching water, and this significant time cost has been associated with leaving young children alone for 1 or more hours, 1 or more days per week, or overall insufficient low childcare (Geere & Hunter 2020). Furthermore, previous research has shown that poor water access is associated with the limited cleaning and use of sanitation facilities. Therefore, the availability of sanitation facilities does not guarantee their use (Tsai *et al.* 2016; Workman & Ureksoy 2017; Jacob Arriola *et al.* 2020).

Cameroon, located in Central Africa, experiences high levels of undernutrition among children, with 32% of children under five experiencing stunting and 15% being underweight (UNICEF/WHO/World Bank 2020). Cameroon, like many other countries in sub-Saharan Africa, faces economic water insecurity, with rural areas experiencing the highest burden of limited access to safely managed water, such as water sources located on premises, available when needed, and free from biological and chemical contaminations. In our previous local study in the West Region of Cameroon with 134 mothers or caretakers of young children, we found that poor water access involving long walking distance to water source was associated with the lower availability of water at the household level. Poor water access was also associated with infrequent handwashing and the higher incidence of diarrhea among children. In limited water access, caretakers prioritized water use and saved water for drinking and cooking than water for handwashing and cleaning (Nounkeu *et al.* 2019).

To expand this previous research to the national level, we used the Demographic and Health Survey (DHS) data with the main objective of examining how water access and sanitation services are related to diarrhea, diet diversity, and anemia among infants and toddlers in rural households in Cameroon. The study's focus on infants and toddlers in rural households will help design recommendations and policies that promote a healthy start for children, since the occurrence of gastrointestinal infections especially during infancy and toddlerhood can cause undernutrition and irreversible damage to individual's growth and development.

METHODS

Study sample

This cross-sectional study included the Cameroon 2011 Demographic and Health Survey (DHS VI) Data. This survey questionnaire consists of frames of reference: Household; Woman's and Man's. For our study, specifically data from household and woman's questionnaires were used for the analyses. The household-level questionnaire assessed water access and the use of sanitation facility, while the woman's questionnaire collected information related to infant's health and nutrition from their mother or caregiver. The survey was implemented by Cameroon's National Institute of Statistics in collaboration

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with the Ministry of Public Health. Details about the sampling, response rate, and survey sections are available through the final report (Cameroon DHS Final Report 2012). The Cameroon DHS is designed to provide data at the national level by rural and urban areas. Since the focus of this study was on health outcomes in infants and toddlers in rural areas, the selection of participants and analyses was restricted to households in rural areas having at least one child between 6 and 24 months of age. Before conducting the analyses, the DHS-computed sampling weights were used to account for differences in the probability of selection (Rutstein & Rojas 2006). The final sample size of this study was 2,129 infants and toddlers or households.

Main variables

Water and sanitation

The following water-related questions in the DHS VI were used to create water service variables:

(Q1) What is the main source of drinking water for members of your household? (Responses: The options for the Q1 included a long list of options ranging from piped water, tube well to rainwater and surface water.)

(Q2) Where is that water source located? (Responses: in own dwelling/plot/yard or elsewhere.)

(Q3) If the water source is not in its own dwelling/yard/plot, how long does it take to go there, get water, and come back? (Responses: recording round-trip time in minutes.)

Based on the responses from these three questions, a composite variable combining time and water source was created using the following Joint Monitoring Program's service ladder for drinking water: (1) safely managed: drinking water from an improved water source which is located on premises; (2) basic: drinking water from an improved source with collection time or round-trip of 30 min or less; (3) limited: drinking water from an improved source where collection time exceeds more than 30 min; (4) unimproved: drinking water from an unprotected dug well or unprotected spring; and (5) no service: drinking water collected directly from surface water sources such as river, pond, lake, and stream (WHO & UNICEF 2021).

For assessment of sanitation facilities, the following two questions from the DHS VI were used:

Q1: What kind of toilet facility do members of your household usually use? (Responses: the involved long list of options, such as flush/pour-flush toilet, pit latrine with or without slab, bucket toilet, composting toilet, and no facility/bush/field).

Q2: Do you share this toilet facility with other households? (This follow-up question was asked for all the responses except no facility/bush/field. The responses provided were: Responses: Yes or No.)

Based on the responses, the following three categories were created: (1) improved sanitation: flush or pour-flush toilet or pit latrine with slab facility involving safe disposal of excreta; (2) unimproved sanitation involving the use of pit latrines without a slab or platform or hanging latrines or bucket latrines; (3) open defecation. Since sharing of the improved sanitation facility was not common, the categories of basic and limited sanitation involving sharing of latrines with two or more households were not included in the analyses.

Outcome variables

Three outcome variables used were: (i) diarrhea within the past 2 weeks; (ii) diet diversity (consuming <4 versus ≥ 4 food groups); and (iii) anemia status. Infants and toddlers selected for the analyses were generally the youngest children of the household. For the diarrhea status, the following question with the Yes or No option was used: Has (youngest child name) had diarrhea in the last 2 weeks. For diet diversity, mother or caretaker was asked whether the child had eaten foods from the following seven food groups yesterday during the daytime or at night: (1) grains, roots, and tubers; (2) legumes and nuts; (3) dairy products (infant formula, milk, yogurt, and cheese); (4) flesh foods (meat, fish, poultry, and liver/organ meats); (5) eggs; (6) vitamin A-rich fruits and vegetables; and (7) other fruits and vegetables. The collection of diet diversity data in the DHS is restricted to up to 23 months of age, resulting in a sample size of 1,835 comprising 6–23 months infants and toddlers. Using standard scoring for the DHS VI, the diet diversity score was dichotomized as: <4 versus ≥ 4 food groups.

Anemia status was diagnosed with a blood test. Generally, children aged 6 months and older are tested for anemia through a finger prick, while in the case of infants aged younger than 6 months, heel prick blood testing is done using standard testing systems. The test results are then adjusted for altitude before grouping children into the following anemia status categories:

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(i) no anemia (≥11.0 g/dl), (ii) mild anemia (10–10.9 g/dl), (iii) moderate anemia (7–9.9 g/dl), and severe anemia (<7 g/dl) (Hruschka *et al.* 2020). For this study, anemia status was dichotomized into: no anemia (≥11.0 g/dl) or any anemia (<11.0 g/dl). The hemoglobin value was missing for 1,068 infants and toddlers, and two infants were excluded as outliers (hemoglobin <0.6). Hence, for anemia status, the total sample size was 1,059 infants and toddlers.

Statistical analyses

The data analyses were performed in SAS version 9.4 (SAS Institutes, Cary, NC). Statistical significance was set at the threshold of 5% ($p \leq 0.05$). Descriptive analyses were carried out to determine the prevalence of diarrhea and anemia among infants and toddlers. The associations between household-level water and sanitation services with diarrhea status, diet diversity, and anemia among infants and toddlers were used via the LOGISTIC procedure in SAS. To ensure accurate standard errors, sampling weights were applied to all models to account for the stratified sampling approach used to gather DHS data.

RESULTS

Study participants

Our analysis sample comprised of 2,129 rural-dwelling infants and toddlers with an average age of 14.6 months. As shown in Table 1, 50.4% of infants and toddlers were female. A female caregiver, on average, was 26.7 years who is resided in a household of an average size of 8 and about one-third of them reported having at least secondary education. Furthermore, as shown in Table 1, about half of them were self-employed working in small-scale agriculture. From the five wealth categories of richest

Table 1 | Description of socio-demographic characteristics of infants and toddlers in living in rural households in Cameroon ($n = 2,129$)

Socio-demographics	Mean ± SD
Mother's/caretaker's age (in years)	26.7 ± 6.70
Index child's age (in months)[a]	14.6 ± 5.35
Household size	8.2 ± 4.51
Total number of children living in the household (<18 years)	2.4 ± 1.47
	n (%)
Index child's gender	
Female	1,072 (50.4)
Male	1,057 (49.6)
Index child takes iron pill[b]	
No	1,926 (91.6)
Yes	176 (8.4)
Mother's/caretaker's education	
No formal schooling	662 (31.1)
Incomplete primary	594 (27.9)
Complete primary	394 (18.5)
Some secondary or higher	479 (22.5)
Mother's/caretaker's marital status	
Married/having a partner	1,863 (87.5)
Single or widower	266 (12.5)
Mother's/caretaker's occupation	
Agricultural – self-employed	1,062 (49.9)
Not working	438 (20.6)
Sales	383 (18.0)
Other[b]	246 (11.5)

[a]Youngest child of 6–24 months of age in the household.
[b]Other refers to skilled labor, manual, seasonal work, and other related work, and information were missing for 27 children, total sample size 2,102.

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to poorest, most households were in the bottom two of poorer and poorest wealth categories (70.3%), with only 19.4% reported having electricity in the household. The majority owned their farm (92.3%) and livestock (69.8%).

In reviewing water access and sanitation services, most study participants utilized well water as their primary water source (46.7%), followed by spring water (22.7%) and rainwater (17.4%) (Table 2). In case of rainwater, it was assumed that survey interviews for those households might have occurred during the wet season. The use of household piped connection was rare, and bottled water for drinking was not reported. With regard to proximity to the primary water source, more than half of the participants reported having a water source either near the household or within 30 min in a round-trip (Table 2). However, when combining water source and distance, only about one-third of our sample had access to an improved water source within a 30-min round-trip. In case of sanitation, improved sanitation facilities, such as flush toilet, pour-flush toilet, or pit latrine with slab facility involving safe disposal of excreta, were reported by only 32.4% of the households.

About one-third of infants and toddlers in our sample experienced diarrhea within the past 2 weeks (32.3%), while 69% consumed less than four different food groups on the day prior to the interview. Additionally, most children were experiencing some level of anemia (75.5%, mild/moderate/severe).

Results from the logistic regression analysis, including coefficients and corresponding odds ratios for the probability of diarrhea, lack of diversity in the diet, and anemia, are provided in Table 3. Those with lower levels of water service had a higher

Table 2 | Description of simple and combined distributions of water and sanitation services among rural households in Cameroon ($n = 2,129$)

	n **(%)**
Water service	
Source of drinking water	
Individual well (tube, protected, and unprotected)	994 (46.7)
Spring water (protected and unprotected)	482 (22.7)
River/rainwater	371 (17.4)
Public tap/standpipe	223 (10.5)
Household piped connection (to dwelling or yard)	47 (2.2)
Small tank/other	12 (0.5)
Purchase of bottled water	0 (0)
Safety of water source	
Improved	825 (38.7)
Unimproved	887 (41.7)
Surface water/other	417 (19.6)
Time to water source	
In dwelling/on plot	105 (4.9)
Elsewhere (within 30 min)	1,226 (57.6)
Elsewhere (30 min or farther)	798 (37.5)
Combined water and sanitation service distribution	
Water service	
Safely managed (water in dwelling/on plot and improved water source)	39 (1.8)
Basic (improved source within 30 min)	595 (28.0)
Limited (improved source 30 min or farther)	365 (17.2)
Unimproved source	754 (35.4)
Surface water	376 (17.6)
Sanitation	
Improved	688 (32.4)
Unimproved	1,195 (56.2)
Open defecation/other	246 (11.4)

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Table 3 | Logistic regression coefficients and odds ratios (95% CI) for the probability of diarrhea, lack of diverse diet, and anemia for infants and toddlers living in the rural household in Cameroon ($n = 2,129$)

	Diarrhea[a]			Diet diversity[b,c]			Anemia[d,e]		
	β (SE)	OR (95% CI)	*p*-value	β (SE)	OR (95% CI)	*p*-value	β (SE)	OR (95% CI)	*p*-value
Sex									
Male (ref)	–	–	–	–	–	–	–	–	–
Female	0.030 (0.094)	1.031 (0.857,1.240)	0.748	−0.004 (0.108)	0.996 (0.806, 1.230)	0.970	−0.471 (0.148)	0.624 (0.467, 0.835)	0.002
Water service									
Safely managed (ref)	–	–	–	–	–	–	–	–	–
Basic	0.887 (0.529)	2.428 (0.861, 6.842)	0.09	0.407 (0.403)	1.503 (0.682, 3.311)	0.312	−0.620 (0.753)	0.538 (0.123, 2.353)	0.410
Limited	1.169 (0.532)	3.219 (1.135, 9.126)	0.028	0.474 (0.410)	1.606 (0.719, 3.584)	0.248	−0.616 (0.760)	0.540 (0.122, 2.393)	0.417
Unimproved	1.088 (0.528)	2.968 (1.055, 8.349)	0.039	0.859 (0.405)	2.361 (1.068, 5.217)	0.034	−0.315 (0.757)	0.730 (0.166, 3.214)	0.677
No service (surface water)	1.089 (0.532)	2.973 (1.048, 8.432)	0.041	1.158 (0.414)	3.182 (1.413, 7.165)	0.005	−1.051 (0.756)	0.350 (0.079, 1.538)	0.164
Sanitation									
Improved (ref)	–	–	–	–	–	–	–	–	–
Unimproved	0.129 (0.107)	1.137 (0.922, 1.403)	0.230	0.300 (0.115)	1.350 (1.078, 1.691)	0.009	−0.189 (0.166)	0.828 (0.597, 1.146)	0.255
Open defecation	0.412 (0.154)	1.510 (1.117, 2.041)	0.007	1.453 (0.234)	4.275 (2.704, 6.759)	<0.001	0.016 (0.251)	1.016 (0.621, 1.663)	0.948

[a]Probability of having diarrhea within the past 2 weeks versus no diarrhea.
[b]Probability of fed/consumed <4 different food groups versus 4 or more food groups out of 7 in the past day.
[c]Based on the DHS guidelines, diet diversity was only computed for children aged 6 to <24 months (i.e., excluded children 24 months of age) who had complete dietary data ($n = 1,835$).
[d]Probability of having anemia (i.e., altitude adjusted hemoglobin <11.0 g/dl) versus not anemic. For this outcome specifically, intake of iron pills was additionally included as a covariate, though it was not very common (see Table 1) and non-significant (OR 1.106, 95% CI 0.626–1.956).
[e]The hemoglobin value was missing for 1,068 infants and toddlers and two infants were excluded as outliers (hemoglobin <0.6); hence, for anemia status, the total sample size was 1,059 infants and toddlers.

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probability of diarrhea within the past 2 weeks. Specifically, the odds of diarrhea for those whose primary drinking water source was categorized as limited, unimproved, or surface water were approximately three times higher than those with a safely managed drinking water source. For those whose sanitation level was categorized as open defecation, the odds of having diarrhea were 50% higher than those with improved sanitation ($p = 0.007$). No significant differences in odds of diarrhea were seen between improved and unimproved sanitation facilities.

There were no observed differences in the odds of having a diverse diet for individuals with the three highest levels of water service (safely managed, basic, and limited); however, children with unimproved or surface water were less likely to have a diverse diet when compared with children with safely managed water ($p = 0.034$ and 0.005, respectively). Similar results were seen for those experiencing limited sanitation or open defecation. Compared with improved sanitation, the odds of consuming less than four food groups were 1.35 and 4.275 times higher in limited sanitation and open defecation conditions, respectively. Finally, differences in the probability of anemia for any category of water service or sanitation level all failed to reach significance. However, the odds of anemia were approximately 38% lower for females when compared with males ($p = 0.002$).

DISCUSSION

Safe drinking water and improved sanitation are keys to health and environmental protection. The 2017 Join Monitoring Program report on drinking water reported that eight out of ten people without access to safely managed drinking water lived in rural areas, with sub-Saharan Africa affected the most (WHO & UNICEF 2017). Similarly, the use of surface water sources, such as ponds or other unimproved sources, was common in our study sample. The results of this study also show the use of improved sanitation facilities that safely separate human waste from human contact is uncommon among the population group of the rural poor. This lack of basic services and the resulting elevated risk of poor health and nutrition among infants and toddlers have led to calls for action and international cooperation to build capacity and infrastructure for improved water- and sanitation-related services in rural Africa.

As reflected in the water service ladder, time cost is an important factor to consider in determining water access at the household level. The results of this study showed that basic-to-limited water access requiring 30 min or more per round-trip was associated with an increased risk of diarrhea among infants and toddlers. Studies in Kenya, Lesotho, and Uganda have shown that women make multiple daily trips to water sources to fetch sufficient amounts of water for their households (Tsai *et al.* 2016; Workman & Ureksoy 2017; Collins *et al.* 2019). Consequently, spending even 30 min or less per round-trip results in several hours per day spent water fetching. Such excess time cost potentially leads to the following pathways, all of which increase the odds of diarrhea occurring among infants and toddlers: (1) the prioritization of water for cooking and drinking versus for cleaning activities; (2) the reuse and recycling of water causing cross-contamination; and (3) the excess time spent on water fetching reducing time for self-care, childcare, and other wellness activities. Furthermore, our previous qualitative studies have shown that excess time spent on water fetching leads to limited water use, including the limited use of sanitation facilities, since they require regular cleaning and water use (Nounkeu & Dharod 2020). In reviewing integrated WASH and nutrition randomized trials, it was concluded that without an adequate supply of water, the uptake of sanitation and handwashing will be difficult at the household level (Bekele *et al.* 2020).

In this study, it was found that open defecation was associated with higher odds of diarrhea among infants and toddlers. This is unsurprising because previous studies have shown that the ingestion of bacteria and pathogens from surroundings during free play and crawling is a common route of infection transmission among infants and toddlers in rural areas (Ngure *et al.* 2014). Other WASH interventions have also involved the free distribution of playpens to provide a fecal-free environment for infants and toddlers. For instance, Reid *et al.* (2018) piloted a Baby WASH intervention in a rural Zambia where households were provided with playpens or the construction of specific play areas for infants and young children. The initial results showed that the protected play area prevented infants and toddlers from ingesting soil and livestock feces, and thus, decreased the risk of infection and diarrhea. In this study, we found a direct connection between open defecation and diarrhea among children. However, in the recent large-scale randomized control trials (WASH Benefits and SHINE), a decrease in the diarrheal rate was seen in only one of the three sites, and improvement in linear growth was not seen in any of the sites (Cumming *et al.* 2019). In the consensus, it was noted that the transformative level changes in involving universal improvement in water and sanitation infrastructure at the community level is critical to prevent cross-contamination, diarrhea and related poor health outcomes. Based on the review of other integrated interventions, we concluded

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that first and foremost W of WASH needs to be addressed. Changes in hygiene behavior and the prevention of cross-contamination cannot be expected until households are water secure or have access to the sufficient amount of clean water at all times (Nounkeu & Dharod 2021). For instance, in the development of household level water insecurity scale in Cameroon called WATINE-17, it was found that the use of water for household activities, including cooking and daily intake of water, decreased when 'W' was limited (Nounkeu *et al.* 2021).

Interestingly, unimproved or no water service was also associated with a lack of diet diversity among infants and toddlers. This relationship was also seen with sanitation. In the study, the majority of the households were in the low wealth quintile and may have also been experiencing food insecurity. Low income and food insecurity are directly related to the lack of variety in the diets of infants and toddlers in sub-Saharan Africa (FAO/IFAD/UNICEF/WFP/WHO 2020). Specifically, in Cameroon, the prevalence of stunting among children under 5 is 28.9%, with children living in rural areas being the most affected by undernutrition and lack of variety in the diet (UNICEF/WHO/World Bank 2020).

In examining the role of water in diet diversity, first, water is critical to ensure food availability for rural households. With limited water access, women have difficulty managing home gardens and introducing variety into their diets (WHO/UNICEF 2017). Second, it is also possible that the overexertion resulting from water fetching may not allow caretakers to provide optimal care and nurturing, including introducing a variety of foods in feeding young children. For instance, in a study in Lesotho (Workman & Ureksoy 2017), it was found that women often put their young children in the care of older children or neighbors to walk long distances and make multiple trips to fetch water.

In case of anemia, no significant association was found. The majority of infants and toddlers experienced some levels of anemia; consequently, it is possible that the lack of variability in anemia status with a high number of missing cases might have influenced the findings. In the future, an investigation of how WASH services mediate anemia is warranted. Furthermore, interventions involving safe ways to recycle water at the household or community level, such as constructed wetlands and biogas settlers, are critical to address limited water access and related nutrition issues in rural areas in Africa (de Miguel *et al.* 2020).

Although this study adds to the scant literature on the water and sanitation situation of rural households in sub-Saharan Africa, it is not without limitations. Data used for this study were from 2011 since the latest DHS survey (2018) was unavailable at the beginning of the analyses. Improved drinking water sources are those which, by nature of their design and construction, provide clean and safe water. However, the 'water-washed' transmission from poor fetching and storage is also high. In the future, the measurement of water quality at the household level is warranted to fully understand the impact of water access on diarrhea and related outcomes. Most of the households were either poor or poorest with no source of set income or livelihood; hence, any adjustment by income and other wealth-related indicators such as having a bank account was not possible. However, our study samples are highly representative of rural households in Africa having a similar living condition of having limited or no household income. The calculated diet diversity scores were based on the consumption of a particular food group within the previous 24 h, which may not be representative of the daily intake, especially significant difference in a variety of the diet is seen between wet and dry seasons in rural areas in developing countries. It was not possible to distinguish between interviews done in the wet versus dry season.

This study outlined further evidence of the interconnectedness of water, sanitation, and undernutrition. Results of this study highlight that achieving SDG #6, universal access to water and sanitation, will lead to success in meeting other SDGs, such as #3 good health and wellbeing and #4 gender equality.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories (https://dhsprogram.com/methodology/survey/survey-display-337.cfm).

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First received 19 May 2021; accepted in revised form 24 October 2021. Available online 9 November 2021

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