UGANDA NATIONAL INSTITUTE OF PUBLIC HEALTH
Quarterly Epidemiological Bulletin: October-December, 2022
Volume 7 / Issue 4 /Article No. 2

Factors Associated with Acute Watery Diarrhea among Children Aged 0–59 Months in Obongi District, Uganda, April 2022: A Case–Control Study

Authors: Edirisa Juniour Nsubuga[1]*, Jireh Kirabo[2], Andrew Kwiringira[1], Linus Andaku[3], Immaculate Ampeire[4], Fred Nsubuga[4], Benon Kwesiga[1], Lilian Bulage[1], Daniel Kadobera[1], Paul Edward Okello[1], Alex Riolexus Ario[1]
Affiliations: [1]Uganda Public Health Fellowship Program, Uganda National Institute of Public Health, Kampala, Uganda, [2]Makerere University School of Public Health, Kampala, Uganda, [3]District Health Office, Obongi District Local Government, Uganda, [4]Uganda National Expanded Programme on Immunization, Ministry of Health, Kampala, Uganda
***Correspondence:** Email: nsubugaeddiej@musph.ac.ug, Tel: +256704131375

Summary

Introduction: Diarrheal diseases are a leading cause of morbidity in Ugandan children. Despite having a 2-dose rotavirus vaccination coverage of >95% from 2019 to 2021, Obongi District consistently reported the highest incidence of acute watery diarrhea (AWD) in the country during the period January 2017-April 2022. We assessed the factors associated with AWD among children aged 0-59 months in Obongi District in the month of April 2022.

Methods: We conducted a 1:2 unmatched case–control study. We defined a case of AWD as the passage of ≥3 loose/liquid stools per day with negative malaria and pneumonia tests in a child aged 0-59 months residing in Itula or Parolinya subcounties from 1-30 April 2022. We reviewed medical records and interviewed case-persons' caregivers. A control was a child aged 0-59 months from a neighboring household with no AWD from 1-30 April. We used logistic regression to identify factors associated with AWD.

Results: Among 193 cases and 386 controls, 104 (54%) cases and 183 (47%) controls were male (p=0.14) and 58 (30%) cases and 127 (33%) controls were aged 12-23 months (p=0.56). In total, 187 (97%) cases and 369 (96%) controls had received at least one dose of rotavirus vaccine (p=0.45), and 58 (30%) cases and 120 (34%) controls (p=0.34) treated their drinking water by boiling/ using chlorine. Suffering from a comorbidity (undernutrition, diabetes mellitus, and/or HIV) (AOR=12; CI: 2.5-53), having a caregiver who did not wash hands with soap and water after visiting the toilet (AOR=3.9; CI: 1.2-13), and living in households that used borehole water versus piped water (AOR=4.0; CI: 1.7-9.6) were associated with AWD.

Conclusion: Comorbidities, failure of caregivers to wash their hands with soap after visiting toilets, and use of borehole water were associated with AWD. Community sensitization on handwashing at critical times, using clean water and soap, and expanded use of piped water could reduce AWD incidence in this area.

Introduction

Acute watery diarrhea (AWD) is the second leading cause of mortality among children aged 0–59 months worldwide, causing an estimated 525,000 deaths and 1.7 billion child cases annually (1). In Uganda, acute watery diarrhea is among the top ten causes of morbidity in children aged 0–59 months, accounting for up to 8% of all outpatient visits (2). The trends and spatial distribution of acute watery diarrhea among children aged 0–59 months from 2016–2021 showed an average national incidence of 12 (±2.1) cases per 100 children (E.N., unpublished data).

Studies in Ethiopia and Zambia showed that the use of unprotected water sources, age of the child caregiver, child weaning time, family size, low maternal education, poor sanitation, contaminated water source, duration of breast feeding, failure to wash hands, absence of rotavirus vaccination, failure to dispose of feces hygienically, and adequate food hygiene were significant predictors of AWD among children aged 0–59 months (3-9). Other studies showed that child-related factors such as sex (10), age (11), and malnutrition (12) were associated with childhood diarrhea.

The World Health Organization (WHO) recommends the use of the rotavirus vaccine as part of a comprehensive strategy to control AWD in addition to treatment packages and preventive strategies such as oral rehydration salt (ORS) solution, zinc supplements, rehydration with intravenous fluids (in cases of severe dehydration or shock), promotion of early and exclusive breastfeeding, continuous breast feeding (breast milk is an excellent rehydration fluid), hand washing, supply of clean and safe water and sanitation, and provision of nutrient-rich foods (13, 14). The majority of children (90%) who receive the rotavirus vaccine are protected from severe rotavirus diarrhea, and approximately 70% of them are completely protected from all forms (severe and mild) of rotavirus disease (15). Before the introduction of the rotavirus vaccine in 2018, rotavirus diarrhea was responsible for nearly 40% of all AWD cases and nearly 11,000 deaths among children under 5 years of age in Uganda annually (14, 16). In addition to the WHO recommended treatment packages and preventive strategies for AWD that were already in use (17), on 26 June 2018, the government of Uganda through the Ministry of Health (MoH) introduced the rotavirus vaccine into the Uganda National Expanded Program on Immunization (UNEPI) to protect children from AWD (14, 16). The rotavirus vaccine is free and available in health facilities and through community vaccination outreaches throughout the country (18). Uganda immunizes its children at 6 and 10 weeks of age with an interval of at least 4 weeks between doses (18).Acute watery diarrhea among children aged 0–59 months is a notifiable disease in Uganda (19). AWD surveillance is passive as part of the national integrated disease surveillance and response system (19). When an AWD case is diagnosed at a health facility, the information about that case is filled into the health facility outpatient register or inpatient register depending on whether the patient was treated as an outpatient or inpatient, respectively (19-21). At the end of every month, the total number of AWD cases at the health facility are added and reported to the district and the MoH through the health unit outpatient monthly report (HMIS 105) and the health unit inpatient monthly report (HMIS form 108) (19-21). These reports are then uploaded into the electronic district health information system version 2 (DHIS2), where they are easily accessed by MoH policy makers and other stakeholders (19, 22). Despite having a 2-dose rotavirus vaccination coverage of >95% from 2019–2022, Obongi District consistently reported the highest incidence rates of AWD in Uganda, with >45 cases/100 children aged 0–59 months each year from 2017–2021 (E.N., unpublished data). Identifying factors associated with AWD among children aged 0–59 months in Uganda would provide evidence to guide the Ministry of Health (MoH), Obongi District local government, and implementing partners to control AWD in this age group. To generate this evidence, we identified the factors associated with AWD among children aged 0–59 months in Obongi District in the month of April 2022.

Methods

Study setting

Obongi District is a refugee-hosting district in Uganda, primarily hosting refugees from South Sudan. Its refugee population was estimated at 128,500 persons (23), outnumbering the host community population, estimated at 50,000 people (24). It was estimated that 12% of refugees in Obongi District were children aged 0–59 months (23). Obongi District is in the West Nile Region of Uganda and is bordered by Moyo District in the north, Adjumani District in the east, Yumbe District in the west, and Madi-Okolo District in the south. It comprises six subcounties (Aliba, Ewafa, Gimara, Itula, Obongi Town Council, and Parolinya) (25), of which Itula and Parolinya contributed more than 75% of the AWD cases among children aged 0–59 months in the district (22). The current safe water coverage of Itula and Parolinya subcounties is 11,379 (95%), with only 73 (57%) of all water sources, 2 (60%) of the shallow wells, 52 (49%) of the deep boreholes, 6 (86%) of the rainwater tanks, and 13 (100%) of the tap stands in a functional state as of September 2022 (26). The household latrine coverage of Itula and Parolinya subcounties was 93.4% as of September 2022 (27).

Study design and population

We conducted an unmatched case–control study in Itula and Parolinya subcounties to assess the factors associated with AWD among children aged 0–59 months. The study respondents were child caregivers living in Itula and Parolinya subcounties of Obongi District in Uganda. We defined a case of AWD as the passage of ≥3 loose or liquid stools per day with negative malaria and pneumonia tests in a child aged 0–59 months residing in Itula or Parolinya subcounties, Obongi District, from 1–30 April 2022. A control was a child aged 0–59 months who did not suffer from AWD from 1–30 April 2022 and was from households that had no case in them residing in Itula or Parolinya Subcounties, Obongi District, from 1–30 April 2022. Overall, we studied children aged 6–59 months residing in Itula and Parolinya subcounties, Obongi District, from 1–30 April 2022.

Sample size

The sample size was determined using the Fleiss formula, which is one of the double population proportion formulas. The required sample size was calculated using the Fleiss formula in Epi Info software version 7 with the following assumptions: the prevalence of childhood diarrhea derived from a study performed by Asfaha K.F. *et al* in Zana District of Ethiopia in 2015 (28) with 18% and 34% proportions of controls and cases, respectively, using untreated drinking water as one of the determinant factors of acute watery diarrhea morbidity, a ratio of case to control of 1:2, 95% confidence level, 5% margin of error and 80% power to generate a sample size of 549. The final sample size for this study after considering a nonresponse rate of 5% was 579 (193 cases and 386 controls).

Case finding, sampling procedures, and exclusion criteria

We line listed 298 AWD cases among children aged 0–59 months documented in April 2022 in the 10 health facilities of Itula and Parolinya subcounties, which contributed more than 75% of the AWD cases in the district. Two hundred forty-one (81%) of the line listed case-patients were refugees from South Sudan. The line list included the child's name, nationality status, next of kin, age, date of visit to the health facility, diagnosis at discharge, laboratory investigations that were done and their results, village, and subcounty of residence. Once we listed all the cases from the outpatient and inpatient registers of the 10 health facilities, we selected the 193 cases from the line list by simple random sampling. Controls of the same age range as the cases were used. Controls were randomly selected from the Community Health Workers' list of households with children aged 0–59 months without any case during the study period (1–30 April 2022). One control was randomly selected from each control household. Cases and controls whose caregivers did not verbally consent to participate in the study and those whose caregivers were not available after two follow-up visits were excluded from the study.

Study variables and data collection

Using a pretested structured electronic questionnaire, we interviewed the mothers or caregivers of the cases and controls. The questionnaire had inbuilt skips, validations, and mandatory fields that ensured high-quality data collection. Variables considered for the case control study were identified after conducting an extensive literature review (3-12, 28). These included child status (case/control), sociodemographic characteristics (nationality of household members; child's sex, age, birth order, and subcounty of residence; household location in a refugee settlement or not, child caregiver's category, age, marital status, and highest level of education attained; sex and occupation of the household head; number of household members and children 0–59 months in the household), child-caring practices (child received rotavirus vaccine, number of rotavirus vaccine doses received, child received measles vaccine, number of measles vaccine doses received, Vitamin A received in the 6 months, time the child spent on exclusive breastfeeding, child's weaning age, age at which the child stopped breastfeeding, caregiver's history of diarrhea, family member's history of diarrhea, and child comorbidity status), and water, sanitation, and hygiene/WASH characteristics (main source of water in the home, roundtrip distance to fetch water, home drinking water treatment, separate storage container for drinking water, toilet facility at home, method of handwashing, caregiver hand washing after visiting the toilet, before feeding the child, after cleaning the child's buttocks, after disposal of child's stool/urine, and before preparing food, hand washing facility at home, hand washing facility near toilet, child stool disposal method, presence of child stool in compound, and presence of refuse in compound).

Data analysis

An Excel dataset from the electronic database server was exported to STATA version 14 for cleaning and subsequent descriptive and statistical analysis. The outcome variable was child status, which was dichotomized by assigning '1' for the cases and '2' for the controls. Descriptive statistics, such as frequencies with percentages, were computed for the different variables. Logistic regression analysis was used at both the bivariate and multivariate levels to generate crude odds ratios (CORs) and adjusted odds ratios (AORs) with 95% confidence intervals (CIs), respectively. Crude associations were determined at bivariate analysis, and a cutoff point of $p \leq 0.1$ was used to consider variables for the logistical regression model using a backward stepwise method where confounders were controlled. If variables included in the multivariate model resulted in a loss of significance, they were removed. Covariates with $p<0.05$ were considered factors associated with the incidence of AWD among children aged 0–59 months in Obongi District. We tested the model using the Hosmer–Lemeshow goodness of fit test. We conducted additional common reference group analysis for the factors that were statistically significantly associated with AWD among children aged 0–59 months in Obongi District using MedCalc's software (29). We also conducted a supplementary analysis of the main source of water in the household and drinking water treatment in the household using a common reference group.

Ethical considerations

The Ministry of Health of Uganda gave the directive and approval to carry out this investigation. In agreement with the International Guidelines for Ethical Review of Epidemiological Studies by the Council for International Organizations of Medical Sciences (1991) and the Office of the Associate Director for Science, CDC/Uganda, it was determined that this activity was not human subject research and that its primary intent was public health practice or disease control activity (specifically, epidemic or endemic disease control activity). This activity was reviewed by the CDC and was conducted consistent with applicable federal law and CDC policy. All experimental protocols were approved by the US CDC human subjects review board and the Uganda Ministry of Health and were performed in accordance with the Declaration of Helsinki. Parental/legal guardian verbal informed consent was obtained on behalf of all the children before the start of each interview since they were aged less than 5 years.

Results

Sociodemographic characteristics of children aged 0–59 months, child caregivers, households, and household heads, Obongi District, Uganda, April 2022

A total of 193 cases and 386 controls with their respective mothers or caregivers were sampled for this study, with a response rate of 100% in both study groups. One hundred seventy-seven (91.7%) cases and 335 (86.8%) controls were refugees, 104 (53.9%) cases and 183 (47.4%) controls were male, 73 (37.8%) cases were aged 6–11 months and 127 (32.9%) controls were aged 24–35 months, 178 (92.2%) cases and 337 (87.3%) controls were living in refugee settlements, and 142 (73.6%) cases and 267 (69.2%) controls were from Itula Subcounty (Table 1).

Regarding child caregivers, 173 (89.6%) cases and 363 (94.0%) controls were cared for by their biological parents, 133 (68.9%) cases and 284 (73.6%) controls had caregivers aged 20–34 years, 142 (73.6%) cases, and 263 (68.1%) controls had caregivers who had attained primary education as their highest level of education (Table 1).

In this study, 117 (60.6%) cases and 243 (63.0%) controls were from households headed by males, and 133 (68.9%) cases and 243 (63.0%) controls were from households in which the households were mainly farmers. One hundred eight (56.0%) cases and 263 (68.1%) controls came from large households having 5–9 members, 128 (66.3%) cases and 240 (62.2%) controls came from households having 2–3 children aged 0–59 months, and 79 (40.9%) cases were second or third borne as 168 (43.5%) controls were fourth borne or more (Table 1).

Table 1.1: Sociodemographic characteristics of respondents in a study assessing the factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Characteristic	Cases (N=193)		Controls (N=386)	
	Frequency (n)	Percent (%)	n	%
Nationality of household members				
Nationals	16	8.3	51	13.2
Refugee	177	91.7	335	86.8
Child sex				
Female	89	46.1	203	52.6
Male	104	53.9	183	47.4
Child age group (Months)				
0-5	25	13.0	46	11.9
6–11	73	37.8	69	17.9
12–23	58	30.0	127	32.9
24–35	28	14.5	81	21.0
36–47	3	1.6	38	9.8
48–59	6	3.1	25	6.5
Household in settlement				
Yes	178	92.2	337	87.3
No	15	7.8	49	12.7
Subcounty				
Itula	142	73.6	267	69.2
Parolinya	51	26.4	119	30.8
Caregiver category				
Parent	173	89.6	363	94.0
Grandmother	15	7.8	19	4.9
Older siblings	5	2.6	4	1.0
Marital status of caregiver				
Married/Cohabiting	165	85.5	358	92.7
Single	14	7.3	19	4.9
Divorced/Separated	14	7.3	9	2.3
Caregiver age group (yrs)				
16–19	27	14.0	22	5.7
20–34	133	68.9	284	73.6
≥35	33	17.1	80	20.7
Highest education level caregiver				
No formal education	26	13.5	55	14.2
Primary	142	73.6	263	68.1
Secondary	22	11.4	63	16.3
Tertiary/University	3	1.6	5	1.3

Table 1.2: Sociodemographic characteristics of respondents in a study assessing the factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Characteristic	Cases (N=193)		Controls (N=386)	
	Frequency (n)	Percent (%)	n	%
Sex household head				
Male	117	60.6	243	63.0
Female	76	39.4	143	37.0
Occupation household head				
Farmer	133	68.9	243	63.0
Unemployed	38	19.7	61	15.8
Business person	16	8.3	54	14.0
Others	6	3.1	28	7.3
HH size				
Small (2–4)	64	33.2	74	19.2
Large (5–9)	108	56.0	263	68.1
Very Large (≥10)	21	10.9	49	12.7
No. of children<5 years				
One	40	20.7	130	33.7
2–3	128	66.3	240	62.2
≥4	25	13.0	16	4.1
Child's birth order				
1^{st} born	44	22.8	70	18.1
2^{nd}–3^{rd} born	79	40.9	148	38.3
≥4^{th} born	70	36.3	168	43.5

Child caring practices of respondents in a study assessing the factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Among the children included in this study, 187 (96.9%) cases and 369 (95.6%) controls had received rotavirus vaccine, of which 159 (85%) cases and 311 (84.3%) controls had received two or more doses. One hundred seventeen (60.6%) cases and 287 (74.4%) controls had received measles vaccines, of which 96 (82.1%) cases and 222 (77.4%) controls had only received one measles vaccine dose. One hundred twenty-nine (66.8%) cases and 252 (65.3%) controls had received vitamin A supplementation in the six months before April 2022, 113 (58.5%) cases and 224 (58.0%) controls were exclusively breastfed for six months or more, 43 (22.3%) cases and 53 (13.7%) controls had caregivers who suffered from diarrhea during the study period, and 85 (44.0%) cases and 89 (23.1%) controls came from households that had another family member who suffered from diarrhea during the study period (Table 2).

Table 2: Child caring practices of respondents in a study assessing the factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Characteristic	Cases (N=193)		Controls (N=386)	
	Frequency (n)	Percent (%)	n	%
Rotavirus vaccine				
Yes	187	96.9	369	95.6
No	6	3.1	17	4.4
Doses of rotavirus vaccine*				
One	28	15	58	15.7
≥Two	159	85	311	84.3
Measles vaccine				
Yes	117	60.6	287	74.4
No	66	34.2	89	23.1
Don’t know	10	5.2	10	2.6
Doses of measles vaccine†				
One	96	82.1	222	77.4
≥Two	21	17.9	65	22.6
Vitamin in previous 6 months				
Yes	129	66.8	252	65.3
No	53	27.5	121	31.3
Don’t know	11	5.7	13	3.4
Time exclusively breastfed				
<6 months	80	41.5	162	42.0
≥6 months	113	58.5	224	58.0
Weaning age				
<6 months	80	41.5	162	42.0
At 6 months	46	23.8	88	22.8
>6 months	67	34.7	136	35.2
Age stopped breastfeeding (month)				
0–6	87	45.1	124	32.1
7–18	39	20.2	71	18.4
≥18	67	34.7	191	49.5
Caregiver suffered from Diarrhea				
Yes	43	22.3	53	13.7
No	150	77.7	333	86.3

Family member suffered from Diarrhea				
Yes	85	44.0	89	23.1
No	108	56.0	297	76.9
Child had a comorbidity				
Yes	31	16.1	9	2.3
No	162	83.9	377	97.7
Child had malnutrition				
Yes	28	14.5	8	2.1
Child had Diabetes Mellitus (DM)				
Yes	4	2.1	1	0.3
Child had HIV				
Yes	2	1.0	0	0

* Among 187 cases and 369 controls that received rotavirus vaccine, †Among 117 cases and 287 controls that received measles vaccine

Water, sanitation, and hygiene characteristics of respondents in Itula and Parolinya Subcounties, Obongi District, Uganda, April 2022

Concerning the water, 114 (59.1%) case and 160 (41.5%%) control households used pipped water as the main source of water, 135 (69.9%) case and 289 (74.9%) control households did not subject drinking water to any form of treatment, and 109 (56.5%) case and 251 (65.0%) control households had separate containers for drinking and domestic water. All case and control households had toilets, 24 (12.4%) case and 97 (25.1%) control caregivers used water and soap to wash their hands, 106 (54.9%) case and 245 (63.5%) control caregivers did not wash their hands after visiting the toilet, and 43 (22.3%) case and 56 (14.5%) control households had child stool in their compounds (Table 3).

Table 3: Water, sanitation, and hygiene characteristics of respondents in Itula and Parolinya Subcounties, Obongi District, Uganda, April 2022

Characteristic	Cases (N=193)		Controls (N=386)	
	Frequency (n)	Percent (%)	n	%
Main source of water				
Pipped	114	59.1	160	41.5
Borehole	79	40.9	226	58.5

Roundtrip distance to fetch water				
≤30 minutes	98	50.8	200	51.8
>30 minutes	95	49.2	186	48.2
Home water treatment*				
Yes	58	30.1	120	34.1
Separate container for drinking water				
Yes	109	56.5	251	65.0
Toilet facility at home (Yes)	193	100.0	386	100.0
Method of handwashing				
Water only	129	66.8	218	56.5
Water and soap	24	12.4	97	25.1
Don't wash hands	40	20.7	71	18.4
Wash hands after visiting the toilet				
Yes	87	45.1	141	36.5
Wash hands before feeding the child				
Yes	161	83.4	317	82.1
Wash hands after cleaning child's buttock				
Yes	143	74.1	301	78.0
Wash hands after disposal of child's stool/urine		0.0		0.0
Yes	149	77.2	303	78.5
Wash hands before preparing food				
Yes	146	75.6	289	74.9
Hand washing facility at home				
Yes	45	23.3	131	33.9
Hand washing facility near toilet†				
Yes	23	51.1	45	34.4
Child stool disposal method				
Toilet	170	88.1	350	90.7
Covered by soil	18	9.3	28	7.3
Open space	5	2.6	8	2.1
Child stool in compound				
Yes	43	22.3	56	14.5
Refuse in compound				
Yes	61	31.6	90	23.3

*Among 352 controls that responded to home water treatment, †Among 45 cases and 131 controls that received rotavirus vaccine

Factors associated with acute watery diarrhea among children aged 0–59 months in Obongi District, Uganda, April 2022

At the bivariate logistic regression analysis stage, children living in households with 5–9 people and more than 10 people had two times the odds of suffering from AWD than those from households with 1–4 people (COR: 2.1; CI: 1.4–3.2 and COR: 2 CI: 1.1–3.7, respectively). Children suffering from a comorbidity such as HIV, malnutrition, and diabetes mellitus (DM) had eight times the odds of suffering from acute watery diarrhea than those who did not have a comorbidity (COR: 8.0; CI: 3.7–17). Children living in households that had no hand washing facility near the toilet had two times the odds of suffering from acute watery diarrhea than those who lived in households that had a hand washing facility near the toilet (COR: 2.0; CI: 1.1–4). Children living in households that had caregivers who did not wash their hands with soap after visiting the toilet had 40 percent more odds of suffering from acute watery diarrhea than those who lived in households that had caregivers who washed their hands with soap after visiting the toilet (COR: 1.4; CI: 1.1–2.0). Children living in households that used borehole water had two times the odds of suffering from AWD than those who lived in households that used pipped water (COR: 2.1; CI: 1.4–2.9) (Table 4).

In the logistic regression model, after controlling for nationality of household members, child birth order, number of household occupants, child sex, household in settlement, and hand washing facility near the toilet, children suffering from a comorbidity such as diabetes and HIV had 12 times the odds of suffering from AWD than those who did not suffer from any comorbidity (AOR: 12; CI: 2.5–53), children whose caregivers did not wash hands with soap and water after visiting the toilet had four times the odds of suffering from acute watery diarrhea than those whose caregivers washed their hands after visiting the toilets (AOR: 3.9; CI: 1.2–13), and children living in households that used borehole water had four times the odds of suffering from acute watery diarrhea than those who lived in households that used pipped water (AOR: 4.0; CI: 1.7–9.6) (Table 4).

Table 4: Bivariate and multivariate logistic regression analysis results of factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Characteristic	Case (N=193)		Control (N=386)		COR (95% CI)	AOR (95% CI)
	n	**%**	**n**	**%**		
Nationality of HH members						
Nationals	16	8.3	335	86.8	1.00	1.00
Refugee	177	91.7	51	13.2	0.6 (0.33–1.1)	1.4 (0.23–7.9)
Child's birth order						
1^{st} born	44	22.8	70	18.1	1.00	1.00
2^{nd}–3^{rd} born	79	40.9	148	38.3	1.2 (0.74–1.9)	0.6 (0.17–1.9)
$\geq 4^{th}$ born	70	36.3	168	43.5	1.5 (0.94–2.4)	0.9 (0.26–2.9)
HH size						
Small (2–4)	64	33.2	74	19.2	1.00	1.00
Large (5–9)	108	56.0	263	68.1	2.1 (1.4–3.2)	1.3 (0.44–3.9)
Very large (≥10)	21	10.9	49	12.7	2.0 (1.1–3.7)	0.9 (0.18–4.6)
Child sex						
Female	89	46.1	203	52.6	1.00	1.00
Male	104	53.9	183	47.4	0.8 (0.55–1.1)	0.5 (0.22–1.2)
Child had a comorbidity						
No	162	83.9	377	97.7	1.00	1.00
Yes	31	16.1	9	2.3	8.0 (3.7–17)	12 (2.5–53)
Household in settlement						
No	15	7.8	49	12.7	1.00	1.00
Yes	178	92.2	337	87.3	0.6 (0.32–1.1)	0.3 (0.04–2.1)
Hand washing facility near toilet†						
Yes	23	51.1	45	34.4	1.00	1.00
No	22	48.9	86	65.6	2.0 (1.1–4)	1.1 (0.48–2.7)
Wash hands with soap after visiting the toilet						
Yes	87	45.1	141	36.5	1.00	1.00
No	106	54.9	245	63.5	1.4 (1.1–2.0)	3.9 (1.2–13)
Main source of water						
Pipped	114	59.1	160	41.5	1.00	1.00
Borehole	79	40.9	226	58.5	2.1 (1.4–2.9)	4.0 (1.7–9.6)

* Significant association at p value < 0.05, †Among 45 cases and 131 controls that received rotavirus vaccine

Additional analysis of the three factors associated with AWD in this study (suffering from comorbidities such as HIV, caregiver's failure to wash hands with soap after visiting the toilet and using borehole water) using a common reference group yielded the following: child comorbidity alone was associated with increased odds of AWD among children (OR: 10, CI: 1.4–93) (Table 5). The odds of AWD among children having a caregiver who did not wash their hands after visiting the toilet and belonging to households that used borehole water were reduced by absence of a comorbidity (OR: 0.3, CI: 0.16–0.54). The odds of AWD among children under the care of caregivers who did not wash their hands after visiting the toilet were increased by suffering from a comorbidity (OR: 4.6, CI: 1.2–18) (Table 5). The odds of AWD among children belonging to households that used borehole water were reduced if their caregivers washed their hands after visiting the toilet and absence of a comorbidity (OR: 0.5; CI: 0.27–0.89) (Table 5).

Table 5: Common reference group analysis of factors associated with acute watery diarrhea among children aged 0–59 months, Obongi District, Uganda, April 2022

Main source of water	Washed hands with soap after visiting the toilet	Child had a comorbidity	Case (N=192)		Control (N=386)		OR (95% CI)
			n	%	n	%	
Pipped (-)	Yes (-)	No (-)	36	44	45	56	1.0
Borehole (+)	No (+)	Yes (+)	6	55	5	45	1.5 (0.42–5.3)
+	+	-	30	19	126	81	0.3 (0.16–0.54)
+	-	+	6	100	0	0	16 (0.88–297)
-	+	+	11	79	3	21	4.6 (1.2–18)
-	-	+	8	89	1	11	11 (1.4–93)
-	+	-	59	35	111	65	0.7 (0.39–1.1)
+	-	-	37	28	95	72	0.5 (0.26–0.85)

* Significant association at p value <0.05

Discussion

Acute watery diarrhea has remained a major cause of morbidity and mortality among children 0–59 months in Uganda despite several interventions that have been put in place to address it. We set out to identify factors associated with AWD among children aged 0–59 months in Obongi District during April 2022. This study showed that suffering from comorbidities such as HIV, caregiver's failure to wash hands with soap after visiting the toilet and using borehole water were the factors associated with acute watery diarrhea among children aged 0–59 months in Obongi District.

In this study, children suffering from comorbidities such as HIV, malnutrition, and DM had higher odds of suffering from acute watery diarrhea than those who did not suffer from any comorbidity. These comorbidities lower the child's immunity, and as a result, the child is predisposed to frequent infections such as AWD from agents and sources from which they would not have been infected (30). Our findings are similar to findings from other studies in Zambia, Ethiopia, and Sudan that showed that comorbidities such as HIV and malnutrition were associated with recurrent AWD among children aged 0–59 months (9, 31, 32).

In this study, we also found that children whose caregivers did not wash their hands with clean water and soap after visiting the toilet had more odds of suffering from AWD than those whose caregivers washed their hands using clean water and soap after visiting the toilet. This is not surprising since hand washing using clean water and soap kills diarrhea-causing organisms and hence reduces its transmission from one person to the other (33). Dirty hands serve as gateways for carrying infectious pathogens to the child's food during feeding of the child, thereby predisposing the child to diarrhea-causing agents (33). Similar findings were also reported in studies carried out in Ethiopia, Zambia, Botswana, Uganda, Tanzania, and Nepal, which also reported that caregivers' hand washing habits, especially of washing hands with clean water and soap at critical times, such as after visiting the toilet, were protective against AWD among children 0–59 months (8, 9, 34-39). However, a study carried out in Ethiopia among children aged 0–59 months did not find any significant association between washing hands at critical times, such as after visiting the toilet, and AWD (28). This might be because that study was carried out among nationals of a fairly stable socioeconomic status compared to the current study, which was conducted primarily among refugees of a low socioeconomic status.

This study showed that children living in households that used borehole water had higher odds of suffering from AWD than those who lived in households that mainly used pipped water that was chlorinated. The chlorine in pipped water disinfects (kills) or inactivates diarrhea-causing organisms, hence rendering it safe for home use (40). Itula and Parolinya subcounties of Obongi District are bounded by the River Nile and have high water tables, implying that toilets in the settlements could have easily contaminated the borehole water since the boreholes are not so deep. A study in Tanzania reported that borehole water was contaminated by fecal material attributed to the entry of sewage (human wastes) into underground water and recommended the treatment or boiling of borehole water before consumption (41). Although boreholes and other ground water sources are classified as improved and safe water sources(42), several microbiological studies of groundwater sources, including boreholes, have reported high rates of *Escherichia coli,* indicating fecal contamination of those sources (43-45). The high population densities in the settlements where these boreholes are located could have exposed them to contamination by children who touch the spouts (water outlets) when fetching water. A study conducted in Zimbabwe reported that although improved sources of water, such as boreholes, generally deliver 'safe' water, a proportion of those sources can easily be contaminated at the point of collection (46). Findings from our study are similar to findings in another study carried out in Nigeria that showed that protected groundwater sources such as boreholes were associated with a high risk of contracting diarrhea (47). However, our findings are contrary to findings in another study conducted in Uganda that showed that children from homes that mainly used borehole water were at reduced risk of AWD than those that mainly used piped water (48). The major difference between that study and the current study is that it was a cross-sectional study using the 2000/2001 Uganda Demographic and Health Survey dataset (48), yet ours is a case control study. That study never gave reasons why children aged 0–59 months from households that used borehole water were at a lower risk of contracting diarrhea compared to those who used pipped water.

Study limitations

This investigation had some limitations. Cases and controls were obtained for the month of April 2022; therefore, the seasonal variations in AWD during the year were not considered. Recall and social desirability bias might have influenced responses to some of the questions that were asked as they depended on the respondent's own memory, and findings from this study are based on self-reported data, although several measures, such as quality control and observation checks, were incorporated into the questionnaire to ensure the accuracy of the data collected.

Conclusions and recommendations

Suffering from a long-term illness such as HIV, malnutrition, and DM, caregivers' failure to wash their hands with soap after visiting toilets, and households using borehole water were associated with AWD among children aged 0–59 months in Obongi District. We recommended health facility management for all children with AWD. We also recommended education of communities on hand washing at critical times using clean water and soap and expanded use of boreholes and piped water.

Conflict of interest

The authors declare that they had no conflict of interest.

Acknowledgments

The authors would like to thank the Obongi District leadership, including the district health team for their permission to conduct the study, the health facility in charges and records assistants of the ten health facilities in Itula and Parolinya subcounties for their permission to review their health facility medical records, and the seven research assistants (Hope Suzan, Charles Amanzuru, Jane Piyo, Denis Obulejo, Abiko Gertrude, Abdulmalik Mahad, and Marupia Dorothy) that helped in data collection.

References

1. Diarrhoeal disease Fact Sheet [Internet]. World Health Organisation (WHO). 2017 [cited 3 October 2021]. Available from: https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease.

2. MoH. Annual Health Sector Performance Report Financial Year 2020/21. www.health.go.ug: Ministry of Health (MoH), Uganda; 2022.

3. Gashaw TA, Walie YM. Prevalence and determinate factors of diarrhea morbidity among under five children in shake zone, Southwest Ethiopia, a community based cross-sectional study. Archives of Community Medicine and Public Health. 2019;5(1):008-14.

4. Getachew A, Guadu T, Tadie A, Gizaw Z, Gebrehiwot M, Cherkos DH, et al. Diarrhea prevalence and sociodemographic factors among under-five children in rural areas of North Gondar Zone, Northwest Ethiopia. International journal of pediatrics. 2018;2018.

5. Getachew B, Mengistie B, Mesfin F, Argaw R. Factors associated with acute diarrhea among children aged 0-59 months in Harar town, eastern Ethiopia. East African Journal of Health and Biomedical Sciences. 2018;2(1):26-35.

6. Gunsa GG, Rodamo KM, Dangiso DD. Determinants of Acute Diarrhoea among Children Aged 6-59 Months in Chiffre District, Southern Ethiopia: Unmatched Case-Control Study. J Gynecol Obstet. 2018;6(2):15-25.

7. Kasye DG, Garoma NH, Kassa MA. Assessment of the prevalence of diarrheal disease under-five children Serbo Town, Jimma Zone South West Ethiopia. Clin Mother Child Health. 2018;15(281):2.

8. Melese B, Paulos W, Astawesegn FH, Gelgelu TB. Prevalence of diarrheal diseases and associated factors among under-five children in Dale District, Sidama zone, Southern Ethiopia: a cross-sectional study. BMC Public Health. 2019;19(1):1-10.

9. Musonda C, Siziya S, Kwangu M, Mulenga D. Factors associated with diarrheal diseases in under-five children: a case control study at arthur davison children's hospital in Ndola, Zambia. Asian Pac J Health Sci. 2017;4(3):228-34.

10. Angesom T. Prevalence and Associated Factors of Diarrhea among Under-Five Children in Laelay-Maychew District, Tigray Region, Ethiopia: Addis Ababa University; 2015.

11. Sinmegn Mihrete T, Asres Alemie G, Shimeka Teferra A. Determinants of childhood diarrhea among underfive children in Benishangul Gumuz regional state, north West Ethiopia. BMC pediatrics. 2014;14(1):1-9.

12. Tamiso A, Yitayal M, Awoke A. Prevalence and determinants of childhood diarrhoea among graduated households, in rural area of Shebedino district, Southern Ethiopia, 2013. Science. 2014;2(3):243-51.

13. Information Sheet: Observed Rate of Vaccine Reactions: Rotavirus Vaccine [Internet]. World Health Organization (WHO). 2014 [cited 03 October 2021]. Available from: https://www.who.int/vaccine_safety/initiative/tools/Rotavirus_vaccine__rates_information_sheet.pdf?ua=1.

14. Government launches new Rotavirus vaccine to protect children in Uganda from diarrhea [Internet]. World Health Organisation (WHO). 2018 [cited 03 September 2021]. Available from: https://www.afro.who.int/news/government-launches-new-rotavirus-vaccine-protect-children-uganda-diarrhea.

15. Vaccines and Preventable Diseases: Rotavirus Vaccination [Internet]. Centres for Disease and Prevention (CDC). [cited 03 October 2021]. Available from: https://www.cdc.gov/vaccines/vpd/rotavirus/index.html.

16. Uganda Rolls out Rotavirus Vaccine into the Routine Immunization Schedule [Internet]. Ministry of Health, Uganda. 2018 [cited 03 September 2021]. Available from: https://www.health.go.ug/2019/12/02/uganda-rolls-out-rotavirus-vaccine-into-the-routine-immunization-schedule/.

17. Uganda Clinical Guidelines 2016: National Guidelines for Management of Common Conditions [Internet]. Ministry of Health, Government of Uganda. 2016. Available from: https://health.go.ug/sites/default/files/Uganda%20Clinical%20Guidelines%202016_FINAL.pdf.

18. MoH. Immunization in Practice and the New Routine Immunization Schedule: A Training Guide for Operational Level Health Workers. Ministry of Health (MoH), The Republic of Uganda; 2022.

19. MoH. National Technical Guidelines for Integrated Disease Surveillance and Response. Third ed: Ministry of Health; 2021.

20. Health Unit Outpatient Monthly Report (HMIS Form 105) [Internet]. Ministry of Health (MoH), Government of Uganda. 2019 [cited 20 October 2022]. Available from:

https://www.malariaconsortium.org/gallery-file/06081045-69-hmis105healthunitoutpatientmonthlyreport.pdf.

21. MoH. Health Unit Inpatient Monthly Report (HMIS Form 108). Kampala, Uganda: Ministry of Health (MoH), Uganda; 2019.

22. Uganda eHMISUganda's Electronic Health Information System: DHIS2 [Internet]. Ministry of Health. Available from: https://hmis.health.go.ug/dhis-web-commons/security/login.action.

23. Uganda - Refugee Statistics January 2022 - Palorinya [Internet]. United Nations High Commission for Refugees (UNHCR). 2022. Available from: file:///C:/Users/HP/Downloads/Palorinya%20Settlement%20Profile_31Jan2022%20(1).pdf.

24. Population & Censuses: Census Population counts (2002 and 2014) by Region, District and Mid Year Population projections (2015-2021) [Internet]. Uganda Bureau of Statistics (UBOS). 2022 [cited 02 March 2022]. Available from: https://www.ubos.org/explore-statistics/20/.

25. Obongi District Investment Profile [Internet]. Ministry of Local Government, Obongi District. 2021. Available from: https://www.ugandainvest.go.ug/wp-content/uploads/2021/08/Obongi-2021.pdf.

26. Obongi District [Internet]. Directorate of Water Development, Ministry of Water and Environment (MWE), Republic of Uganda. 2022 [cited September 4, 2022]. Available from: http://wsdb.mwe.go.ug/index.php/reports/district/146.

27. UBOS. National Population and Housing Census 2014: Area Specific Profiles-Moyo District. Kampala: Uganda Bureau of Statistics (UBOS); 2017.

28. Asfaha KF, Tesfamichael FA, Fisseha GK, Misgina KH, Weldu MG, Welehaweria NB, et al. Determinants of childhood diarrhea in Medebay Zana District, Northwest Tigray, Ethiopia: a community based unmatched case–control study. BMC pediatrics. 2018;18(1):1-9.

29. Odds ratio calculator [Internet]. 2022. Available from: https://www.medcalc.org/calc/odds_ratio.php.

30. Mulholland K. Commentary: comorbidity as a factor in child health and child survival in developing countries. International Journal of Epidemiology. 2005;34(2):375-7.

31. Derseh B, Mruts K, Demie T, Gebremariam T. Co-morbidity, treatment outcomes and factors affecting the recovery rate of under -five children with severe acute malnutrition

admitted in selected hospitals from Ethiopia: retrospective follow up study. Nutrition Journal. 2018;17(1):116.

32. Netsereab TB, Xenos P. Factors Associated with Diarrhea among Children Less Than 5 Years Old in Sudan. Journal of Health Research. 2017;31(Suppl. 2):S209-15.

33. Datta S, Singh Z, Boratne A, Senthilvel V, Bazroy J, Dimri D. Knowledge and practice of handwashing among mothers of under five children in rural coastal South India. International Journal of Medicine and public health. 2011;1(1).

34. Nantege R, Kajoba D, Ddamulira C, Ndoboli F, Ndungutse D. Prevalence and Factors Associated With Diarrheal Diseases Among Children Below Five Years in Selected Slum Settlements in Entebbe Municipality, Wakiso District, Uganda. 2022.

35. Arvelo W, Kim A, Creek T, Legwaila K, Puhr N, Johnston S, et al. Case–control study to determine risk factors for diarrhea among children during a large outbreak in a country with a high prevalence of HIV infection. International Journal of Infectious Diseases. 2010;14(11):e1002-e7.

36. Hashi A, Kumie A, Gasana J. Hand washing with soap and WASH educational intervention reduces under-five childhood diarrhoea incidence in Jigjiga District, Eastern Ethiopia: a community-based cluster randomized controlled trial. Preventive medicine reports. 2017;6:361-8.

37. Budhathoki SS, Bhattachan M, Yadav AK, Upadhyaya P, Pokharel PK. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Tropical medicine and health. 2016;44(1):1-7.

38. Tesfaye TS, Magarsa AU, Zeleke TM. Moderate to severe diarrhea and associated factors among under-five children in Wonago District, South Ethiopia: A Cross-Sectional Study. Pediatric Health, Medicine and Therapeutics. 2020;11:437.

39. Kabhele S, New-Aaron M, Kibusi SM, Gesase AP. Prevalence and factors associated with diarrhoea among children between 6 and 59 months of age in mwanza city tanzania. Journal of Tropical Pediatrics. 2018;64(6):523-30.

40. Water Disinfection with Chlorine and Chloramine: Chlorine and chloramine are the major disinfectants used in public water systems [Internet]. Centres for Disease Control and Prevention (CDC). 2020 [cited August 11, 2022]. Available from: https://www.cdc.gov/healthywater/drinking/public/water_disinfection.html.

41. Basamba TA, Sekabira K, Kayombo CM, Ssegawa P. Application of factor and cluster analyses in the assessment of sources of contaminants in borehole water in Tanzania. Polish Journal of Environmental Studies. 2013;22(2):337-46.

42. UN World Water Development Report 2022 'Groundwater: Making the invisible visible': New report : Is the solution to water crises hiding right under our feet? [Internet]. United Nations (UN). 2022 [cited 11 August, 2022]. Available from: https://www.unwater.org/un-world-water-development-report-2022/#:~:text=Groundwater%20presently%20provides%20half%20of,all%20water%20used%20for%20irrigation.

43. Richardson HY, Nichols G, Lane C, Lake IR, Hunter PR. Microbiological surveillance of private water supplies in England–The impact of environmental and climate factors on water quality. Water research. 2009;43(8):2159-68.

44. Kanyerere T, Levy J, Xu Y, Saka J. Assessment of microbial contamination of groundwater in upper Limphasa River catchment, located in a rural area of northern Malawi. Water SA. 2012;38(4):581-96.

45. Howard G, Pedley S, Barrett M, Nalubega M, Johal K. Risk factors contributing to microbiological contamination of shallow groundwater in Kampala, Uganda. Water research. 2003;37(14):3421-9.

46. Gundry SW, Wright JA, Conroy R, Du Preez M, Genthe B, Moyo S, et al. Contamination of drinking water between source and point-of-use in rural households of South Africa and Zimbabwe: implications for monitoring the Millennium Development Goal for water. Water Practice and Technology. 2006;1(2).

47. Hunter PR, Risebro H, Yen M, Lefebvre H, Lo C, Hartemann P, et al. Water source and diarrhoeal disease risk in children under 5 years old in Cambodia: a prospective diary based study. BMC Public Health. 2013;13(1):1-9.

48. Ssenyonga R, Muwonge R, Twebaze F, Mutyabule R. Determinants of acute diarrhoea in children aged 0–5 years in Uganda. East African Medical Journal. 2009;86(11):513-9.