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# Factors associated with acute watery diarrhea among children aged 0–59 months in Obongi District, Uganda, April 2022: A case–control study

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ABSTRACT

*Background:* Diarrheal diseases, are major concerns for Ugandan children; persistent in Obongi District despite high rotavirus vaccination rates (2019–2021). The district recorded the country's highest annual acute watery diarrhea (AWD) incidence from 2017 to 2021. Our study, conducted in April 2022, assessed AWD risk factors among 0–59-month-old children in Obongi.

*Methods:* We conducted a 1:2 (193:386) unmatched case–control study. A case was a child (0–59 months) with ≥ 3 loose/liquid stools/day, negative malaria/pneumonia tests, residing in Itula/Parolinya subcounty from 1 to 30 April 2022. Medical records from 10 facilities were reviewed. Simple random sampling identified cases, who were interviewed, and controls were randomly chosen from non-AWD neighboring households. Child health cards provided vaccination details. 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, 58 (30 %) cases and 127 (33 %) controls were aged 12–23 months, 187 (97 %) cases and 369 (96 %) controls had received at least one dose of rotavirus vaccine, 58 (30 %) cases and 120 (34 %) controls treated drinking water. Comorbidity presence (undernutrition, diabetes, HIV) (AOR = 12; CI: 2.5–53), caregiver's unwashed hands post-toilet (AOR = 3.9; CI: 1.2–13), and borehole vs. piped water (AOR = 4.0; CI: 1.7–9.6) linked to AWD.

*Conclusion:* Modifiable factors, including failure of caregivers to wash their hands with soap after visiting toilets and use of borehole water were associated with AWD, suggesting that 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.

## 1. Background

Acute watery diarrhea (AWD) is the abrupt onset of three or more loose stools per day that can last up to two weeks (Drugs and Diseases: Pediatrics: General Medicine: Diarrhea [Internet]. Medscape., 2020). It 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 (Diarrhoeal disease Fact Sheet [Internet]. World Health Organisation (WHO)., 2017). AWD can be caused by bacteria, viruses, or parasites spread through the fecal oral route (Diarrhoeal disease Fact Sheet [Internet]. World Health Organisation (WHO)., 2017). In Uganda, AWD is among the top ten causes of morbidity in children aged 0–59 months, accounting for up to 8 % of all outpatient visits (MoH, 2022).

The World Health Organization (WHO) recommends the use of the rotavirus vaccine, in addition to treatment packages and preventive

*Abbreviations:* AOR, adjusted odds ratio; AWD, acute watery diarrhea; CI, confidence interval; COR, crude odds ratio; DM, diabetes mellitus; HC, health center; HIV, human immunodeficiency virus; MoH, Ministry of Health; WHO, World Health Organization.

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strategies such as oral rehydration salt solution, zinc supplements, intravenous fluid rehydration (for severe dehydration or shock), early (within one hour), exclusive (for the first 180 days), and continuous breastfeeding, hand-washing, supply of clean and safe water and sanitation, and provision of nutrient-rich foods, as part of a comprehensive strategy to control AWD (Information Sheet: Observed Rate of Vaccine Reactions: Rotavirus Vaccine [Internet]. World Health Organization (WHO)., 2014; Government launches new Rotavirus vaccine to protect children in Uganda from diarrhea [Internet]. World Health Organisation (WHO)., 2018). Ninety percent of children who receive the rotavirus vaccine are protected from severe rotavirus diarrhea, and approximately 70 % are protected from all forms (severe and mild) of rotavirus disease (MOH, 2024). Before the introduction of the rotavirus vaccine in 2018, rotavirus diarrhea was responsible for nearly 40 % of all AWD cases and caused approximately 11,000 deaths among children under 5 years of age in Uganda annually (Government launches new Rotavirus vaccine to protect children in Uganda from diarrhea [Internet]. World Health Organisation (WHO)., 2018; Uganda Rolls out Rotavirus Vaccine into the Routine Immunization Schedule [Internet]. Ministry of Health, Uganda., 2018). In addition to the WHO-recommended treatment packages and preventive strategies for AWD already in use (MOH, 2016), in June 2018, the government of Uganda through the Ministry of Health (MoH) introduced the rotavirus vaccine into the Uganda National Expanded Program on Immunization to protect children from AWD (Government launches new Rotavirus vaccine to protect children in Uganda from diarrhea [Internet]. World Health Organisation (WHO)., 2018; Uganda Rolls out Rotavirus Vaccine into the Routine Immunization Schedule [Internet]. Ministry of Health, Uganda., 2018). The rotavirus vaccine is free and available in health facilities and through community vaccination outreaches throughout the country (MoH, 2022). Uganda immunizes its children at 6 and 10 weeks of age with an interval of at least 4 weeks between doses (MoH, 2022).

Despite having a 2-dose rotavirus vaccination coverage of $>$ 95 % from 2019 to 2022, Obongi District, located in the West Nile Region, consistently reported the highest incidence rates of AWD in Uganda, with $>$ 45 cases/100 children aged 0–59 months each year from 2017 to 2021 (E.N., unpublished data). We evaluated factors associated with AWD among children aged 0–59 months in Obongi District in April 2022 to guide Ministry of Health efforts to reduce AWD in children.

## 2. Methods

### 2.1. Study setting

Obongi District is in the West Nile Region of Uganda and comprises six subcounties (Aliba, Ewafa, Gimara, Itula, Obongi Town Council, and Parolinya) (Ministry of Local Government, 2021). Itula and Parolinya contributed more than 75 % of the AWD cases among children aged 0–59 months in the district (MOH, 2024). Obongi District is a refugee-hosting district, primarily hosting refugees from South Sudan. Its refugee population was estimated at 128,500 persons in January 2022 (UNHCR, 2022), outnumbering the host community population, estimated at 50,000 people (UBOS, 2002). As of September 2022, the safe water coverage of Itula and Parolinya subcounties was 95 %, and the household latrine coverage was 93 % (MWE, 2022; UBOS, 2017).

### 2.2. AWD surveillance in Uganda

AWD among children aged 0–59 months is a notifiable disease in Uganda (MoH, 2021). AWD surveillance is passive as part of the national integrated disease surveillance and response system (MoH, 2021). When an AWD case is diagnosed at a health facility, information about that patient is filled into the health facility outpatient or inpatient register, depending on where the patient was treated (MoH, 2021, 2019a, 2019b). At the end of every month, the total number of AWD cases at the health facility are reported to the district and the MoH through the health unit outpatient monthly report and the health unit inpatient monthly report (MoH, 2021, 2019a, 2019b). These reports are then uploaded into the electronic district health information system version 2, where they are easily accessed by MoH policymakers and other stakeholders (MOH, 2024, 2021).

### 2.3. Study design and population

We conducted an unmatched case–control study in Itula and Parolinya subcounties to assess factors associated with AWD among children aged 0–59 months. The study participants were caregivers of children living in Itula and Parolinya subcounties of Obongi District in Uganda. We defined a case of AWD as the passage of $\geq$ 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 to 30 April 2022. A control was a child aged 0–59 months who did not suffer from AWD from 1 to 30 April 2022 and was from households that had no case in them residing in Itula or Parolinya Subcounties, Obongi District, from 1 to 30 April 2022. We defined a household as a collection of one or more people living either under one roof or more than one roof in the same compound, but sharing meals and having one household head. Overall, we studied children aged 0–59 months residing in Itula and Parolinya subcounties, Obongi District, from 1 to 30 April 2022. We define 0 months as age of a child from birth to less than one month (i.e. less than 28 days).

### 2.4. Sample size

The required sample size was calculated using the Fleiss formula in Epi Info software version 7 with an assumed prevalence of childhood diarrhea of 18 % of controls and 34 % of cases (Asfaha et al., 2018). We used untreated drinking water as one of the determinant factors of AWD, a 1:2 ratio of case to control, a 95 % confidence level, a 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).

### 2.5. 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, village and subcounty of residence, nationality status, next of kin, age, date of visit to the health facility, diagnosis at discharge, and laboratory results. After listing all the cases from the outpatient and inpatient registers of the 10 health facilities, we selected 193 cases from the line list by simple random sampling.

Controls were children aged 0–59 months from households with at least one child aged 0–59 months and without any case during the study period (1–30 April 2022). One control was randomly selected from eligible children in 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.

### 2.6. Study variables and data collection

Using a pretested electronic questionnaire, we interviewed the mothers or caregivers of the cases and controls. Variables considered for the case–control study were identified after extensive literature review and included sociodemographic characteristics, receipt of rotavirus and measles vaccines and vitamin A, breastfeeding practices, caregiver and family members' history of diarrhea, and water, sanitation, and

household and individual hygiene characteristics and practices, presence of diabetes mellitus (DM), malaria, and malnutrition (Asfaha et al., 2018; Gashaw and Walie, 2019; Getachew et al., 2018; Getachew et al., 2018; Gunsa et al., 2018; Kasye et al., 2018; Melese et al., 2019; Musonda et al., 2017; Angesom, 2015; Sinmegn Mihrete et al., 2014; Tamiso et al., 2014). We created a new variable called comorbidity using data collected on undernutrition, diabetes, and HIV, where a child had a comorbidity if they had one or more of undernutrition, diabetes, and HIV. Information about the child's rotavirus and measles vaccination history and the number of doses of each vaccine received was obtained from child health cards. "In cases where the child health cards were not available, we used self-reports, and calendar of local and national events".

### 2.7. Data analysis

We extracted a Microsoft Excel dataset from the electronic database server and exported it to STATA version 14 for cleaning and subsequent descriptive and statistical analysis. The outcome variable was case status. Descriptive statistics were computed for the different variables. We conducted bivariate and multivariate logistic regression analyses to generate crude odds ratios (CORs) and adjusted odds ratios (AORs) with 95 % confidence intervals (CIs), respectively. A cutoff point of $p \leq 0.1$ was used to consider variables for the multivariate logistic regression model using a backward stepwise method and controlling for possible confounders. 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 software (Odds ratio calculator, 2022).

## 3. Results

A total of 193 cases and 386 controls with their respective mothers or caregivers were interviewed with a response rate of 100 %. Cases were generally younger than controls and more often came from small households than controls. Other minor but significant differences existed between cases and controls (Table 1).

### 3.1. 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

Rotavirus vaccine history and doses of rotavirus vaccine received were not different between cases and controls. Cases generally came from households in which other family members suffered from diarrhea during the study period compared to the controls. Other minor but noteworthy differences existed between cases and controls (Table 2).

### 3.2. Water, sanitation, and hygiene 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

All cases and controls came from households with a toilet facility. Cases were more often living in households that did not have a hand washing facility compared to controls. Other minor but significant differences existed between cases and controls (Table 3).

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

Factors associated with AWD among children in bivariate analysis included living in households with 5–9 people (COR: 2.1; 95 % CI:

**Table 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) | | *p*-value |
|---|---|---|---|---|---|
| | Frequency (n) | Percent (%) | n | % | |
| **Nationality of household members** | | | | | |
| Nationals | 16 | 8 | 51 | 13 | 0.08[a] |
| Refugee | 177 | 92 | 335 | 87 | |
| **Child sex** | | | | | |
| Female | 89 | 46 | 203 | 53 | 0.14 |
| Male | 104 | 54 | 183 | 47 | |
| **Child age (months)** | | | | | |
| 0–5 | 25 | 13.0 | 46 | 11.9 | 0.704 |
| 6–11 | 73 | 37.8 | 69 | 17.9 | <0.001[a] |
| 12–23 | 58 | 30.0 | 127 | 32.9 | 0.481 |
| 24–35 | 28 | 14.5 | 81 | 21.0 | 0.060 |
| 36–47 | 3 | 1.6 | 38 | 9.8 | <0.001[a] |
| 48–59 | 6 | 3.1 | 25 | 6.5 | 0.087 |
| Mean (range) | 14 (0–59) | | 20 (0–59) | | <0.01[a] |
| Median (IQR) | 11 (1–48) | | 18 (0–58) | | |
| **Household in settlement** | | | | | |
| Yes | 178 | 92 | 337 | 87 | 0.08 |
| No | 15 | 8 | 49 | 13 | |
| **Subcounty** | | | | | |
| Itula | 142 | 74 | 267 | 69 | 0.27 |
| Parolinya | 51 | 26 | 119 | 31 | |
| **Caregiver category** | | | | | |
| Parent | 173 | 90 | 363 | 94 | 0.06 |
| Grandmother | 15 | 8 | 19 | 5 | 0.16 |
| Older siblings | 5 | 2 | 4 | 1 | 0.14 |
| **Marital status of caregiver** | | | | | |
| Married/Cohabiting | 165 | 86 | 358 | 93 | 0.01[a] |
| Single | 14 | 7 | 19 | 5 | 0.24 |
| Divorced/Separated | 14 | 7 | 9 | 2 | <0.01[a] |
| **Caregiver age (yrs)** | | | | | |
| Mean (range) | 27.5 (16–62) | | 29 (16–58) | | 0.02[a] |
| Median (IQR) | 26 (17–56) | | 28.5 (17–56) | | |
| **Highest education level caregiver** | | | | | |
| No formal education | 26 | 13 | 55 | 14 | 0.82 |
| Primary | 142 | 74 | 263 | 68 | 0.17 |
| Secondary | 22 | 11 | 63 | 17 | 0.12 |
| Tertiary/University | 3 | 2 | 5 | 1 | 0.77 |
| **Sex household head** | | | | | |
| Male | 117 | 61 | 243 | 63 | 0.58 |
| Female | 76 | 39 | 143 | 37 | |
| **Occupation household head** | | | | | |
| Farmer | 133 | 69 | 243 | 63 | 0.16 |
| Unemployed | 38 | 20 | 61 | 16 | 0.24 |
| Business person | 16 | 8 | 54 | 14 | 0.05 |
| Others | 6 | 3 | 28 | 7 | 0.04[a] |
| **HH size** | | | | | |
| Small (2–4) | 64 | 33 | 74 | 19 | <0.01[a] |
| Large (5–9) | 108 | 56 | 263 | 68 | <0.01[a] |
| Very large (≥10) | 21 | 11 | 49 | 13 | 0.53 |
| **No. of children < 5 years** | | | | | |
| One | 40 | 21 | 130 | 34 | <0.01 |
| 2–3 | 128 | 66 | 240 | 62 | 0.33 |
| ≥4 | 25 | 13 | 16 | 4 | <0.01[a] |
| **Child's birth order** | | | | | |
| 1st born | 44 | 23 | 70 | 18 | 0.18 |
| 2nd–3rd born | 79 | 41 | 148 | 38 | 0.55 |
| ≥4$^{th}$ born | 70 | 36 | 168 | 44 | 0.10 |

[a] Significant association at $p < 0.05$, IQR: interquartile range.

**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) | | *p*-value |
|---|---|---|---|---|---|
| | Frequency (n) | Percent (%) | n | % | |
| **Received rotavirus vaccine** | | | | | |
| Yes | 187 | 97 | 369 | 96 | 0.45 |
| No | 6 | 3 | 17 | 4 | |
| **Doses of rotavirus vaccine**[†] | | | | | |
| One | 28 | 15 | 58 | 16 | 0.83 |
| ≥Two | 159 | 85 | 311 | 84 | |
| **Received measles vaccine** | | | | | |
| Yes | 117 | 61 | 287 | 74 | <0.01[a] |
| No | 66 | 34 | 89 | 23 | 0.01[a] |
| Don't know | 10 | 5 | 10 | 3 | 0.11 |
| **Doses of measles vaccine**[‡] | | | | | |
| One | 96 | 82 | 222 | 77 | 0.30 |
| ≥Two | 21 | 18 | 65 | 23 | |
| **Vitamin in previous 6 months** | | | | | |
| Yes | 129 | 67 | 252 | 65 | 0.72 |
| No | 53 | 27 | 121 | 31 | 0.35 |
| Don't know | 11 | 6 | 13 | 4 | 0.19 |
| **Duration of exclusive breastfeeding** | | | | | |
| <6 months | 80 | 41 | 162 | 42 | 0.91 |
| ≥6 months | 113 | 59 | 224 | 58 | |
| **Age at start of weaning** | | | | | |
| <6 months | 80 | 41 | 162 | 42 | 0.91 |
| At 6 months | 46 | 24 | 88 | 23 | 0.79 |
| >6 months | 67 | 35 | 136 | 35 | 0.91 |
| **Age stopped breastfeeding completely (month)** | | | | | |
| 0–6 | 87 | 45 | 124 | 32 | <0.01[a] |
| 7–18 | 39 | 20 | 71 | 18 | 0.60 |
| ≥18 | 67 | 35 | 191 | 50 | <0.01[a] |
| **Caregiver suffered from diarrhea in April 2022** | | | | | |
| Yes | 43 | 22 | 53 | 14 | 0.01[a] |
| No | 150 | 78 | 333 | 86 | |
| **Family member suffered from diarrhea in April 2022** | | | | | |
| Yes | 85 | 44 | 89 | 23 | <0.01[a] |
| No | 108 | 56 | 297 | 77 | |
| **Child had a comorbidity in April 2022**[§] | | | | | |
| Yes | 31 | 16 | 9 | 2 | <0.01[a] |
| No | 162 | 84 | 377 | 98 | |
| **Child had malnutrition** | | | | | |
| Yes | 28 | 15 | 8 | 2 | <0.01[a] |
| No | 165 | 85 | 378 | 98 | |
| **Child had diabetes mellitus (DM)** | | | | | |
| Yes | 4 | 2 | 1 | 0.3 | 0.03[a] |
| No | 189 | 98 | 385 | 97.3 | |
| **Child had HIV** | | | | | |
| Yes | 2 | 1 | 0 | 0 | 0.05 |
| No | 191 | 99 | 386 | 100 | |

[a] Significant association at $p < 0.05$, [†]Among 187 cases and 369 controls who received rotavirus vaccine, [‡]Among 117 cases and 287 controls who received measles vaccine, [§]including malnutrition, DM, and HIV.

1.4–3.2) and > 10 people (COR: 2.0, 95 % CI: 1.1–3.7), suffering from a comorbidity (Human immunodeficiency virus (HIV), malnutrition, and/or DM) (COR: 8.0; CI: 3.7–17), living in households that had no hand washing facility near the toilet (COR: 2.0; CI: 1.1–4), living in households that had caregivers who did not wash their hands with soap after

**Table 3**
Water, sanitation, and hygiene 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) | | *p*-value |
|---|---|---|---|---|---|
| | Frequency (n) | Percent (%) | N | % | |
| **Main source of water** | | | | | |
| Pipped | 114 | 59 | 160 | 41 | <0.01* |
| Borehole | 79 | 41 | 226 | 59 | |
| **Roundtrip distance to fetch water** | | | | | |
| ≤30 min | 98 | 51 | 200 | 52 | 0.82 |
| >30 min | 95 | 49 | 186 | 48 | |
| **Home water treatment**[†] | | | | | |
| Yes | 58 | 30 | 120 | 34 | 0.34 |
| No | 135 | 70 | 232 | 66 | |
| **Separate container for drinking water** | | | | | |
| Yes | 109 | 56 | 251 | 65 | 0.05 |
| No | 84 | 44 | 135 | 35 | |
| **Toilet facility at home** | | | | | |
| Yes | 193 | 100 | 386 | 100 | – |
| No | 0 | 0 | 0 | 0 | – |
| **Method of handwashing** | | | | | |
| Water only | 129 | 67 | 218 | 57 | 0.02* |
| Water and soap | 24 | 12 | 97 | 25 | <0.01* |
| Don't wash hands | 40 | 21 | 71 | 18 | 0.51 |
| **Wash hands after visiting the toilet** | | | | | |
| Yes | 87 | 45 | 141 | 37 | 0.05 |
| No | 106 | 55 | 245 | 63 | |
| **Wash hands before feeding the child** | | | | | |
| Yes | 161 | 83 | 317 | 82 | 0.70 |
| No | 32 | 17 | 69 | 18 | |
| **Wash hands after cleaning child's buttock** | | | | | |
| Yes | 143 | 74 | 301 | 78 | 0.30 |
| No | 50 | 26 | 85 | 22 | |
| **Wash hands after disposal of child's stool/urine** | | | | | |
| Yes | 149 | 77 | 303 | 78 | 0.72 |
| No | 44 | 23 | 83 | 22 | |
| **Wash hands before preparing food** | | | | | |
| Yes | 146 | 76 | 289 | 75 | 0.85 |
| No | 47 | 24 | 97 | 25 | |
| **Hand washing facility at home** | | | | | |
| Yes | 45 | 23 | 131 | 34 | 0.01* |
| No | 148 | 77 | 255 | 66 | |
| **Hand washing facility near toilet**[‡] **(<2 m away)** | | | | | |
| Yes | 23 | 51 | 45 | 34 | 0.05 |
| No | 22 | 49 | 86 | 66 | |
| **Child stool disposal method** | | | | | |
| Toilet | 170 | 88 | 350 | 91 | 0.33 |
| Covered by soil | 18 | 9 | 28 | 7 | 0.40 |
| Open space | 5 | 3 | 8 | 2 | 0.70 |
| **Child stool in compound** | | | | | |
| Yes | 43 | 22 | 56 | 15 | 0.02* |
| No | 150 | 78 | 330 | 85 | |
| **Refuse in compound** | | | | | |
| Yes | 61 | 32 | 90 | 23 | 0.03* |
| No | 132 | 68 | 296 | 77 | |

*Significant association at $p < 0.05$, [†]Among 352 controls who responded to home water treatment, [‡]Among 45 cases and 131 controls who had a hand washing facility near the toilet (within 2 m).

visiting the toilet (COR: 1.4; CI: 1.1–2.0), and living in households that used borehole water (COR: 2.1; CI: 1.4–2.9) (Table 4).

In multivariate logistic regression, after controlling for the nationality of household members, child birth order, number of household occupants, child sex, whether the household was located in the refugee settlement, and presence of a hand washing facility near (less than 2 m from) the toilet, children suffering from a comorbidity (DM, malnutrition and/or HIV) (AOR: 12; CI: 2.5–53), children whose caregivers did not wash hands with soap and water after visiting the toilet (AOR: 3.9; CI: 1.2–13), and children living in households that used borehole water (AOR: 4.0; CI: 1.7–9.6) remained associated with AWD (Table 4).

## 4. Discussion

AWD is a major cause of morbidity and mortality among children 0–59 months in Uganda despite interventions to address it (MOH, 2016), including rotavirus vaccination since 26 June 2018 (Government launches new Rotavirus vaccine to protect children in Uganda from diarrhea [Internet]. World Health Organisation (WHO)., 2018; Uganda Rolls out Rotavirus Vaccine into the Routine Immunization Schedule [Internet]. Ministry of Health, Uganda., 2018). We set out to identify factors associated with AWD among children aged 0–59 months in the high-burden AWD Obongi District. The population had extremely high rates of rotavirus vaccine coverage. Studies in Ethiopia and Zambia showed that the use of unprotected water sources, lower age of child caregivers, child weaning time, family size, low maternal education, poor sanitation, contaminated water sources, shorter 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 acute watery diarrhea among children aged 0–59 months (Gashaw and Walie, 2019; Getachew et al., 2018; Getachew et al., 2018; Gunsa et al., 2018; Kasye et al., 2018; Melese et al., 2019; Musonda et al., 2017). Other studies showed that child-related factors such as sex (Angesom, 2015), age (Sinmegn Mihrete et al., 2014), and malnutrition (Tamiso et al., 2014) were associated with childhood diarrhea. However, in the current study, comorbidities such as HIV, caregiver's failure to wash hands with soap after visiting the toilet, and using borehole water were associated with acute watery diarrhea among children aged 0–59 months in Obongi District.

In this study, children suffering from a comorbidity 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 (Mulholland, 2005). 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 (Musonda et al., 2017; Derseh et al., 2018; Netsereab and Xenos, 2017).

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 their transmission from one person to the other (Datta et al., 2011). 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 (Datta et al., 2011). 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 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 (Melese et al., 2019; Musonda et al., 2017; Nantege et al., 2022; Arvelo et al., 2010; Hashi et al., 2017; Budhathoki et al., 2016; Tesfaye et al., 2020; Kabhele et al., 2018). 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

**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) | *p*-value | AOR (95 % CI) | *p*-value |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | | | | |
| **Nationality of HH members** | | | | | | | | |
| Nationals | 16 | 8 | 335 | 87 | 1.00 | | 1.00 | |
| Refugee | 177 | 92 | 51 | 13 | 0.6 (0.33–1.1) | 0.084 | 1.4 (0.23–7.9) | 0.736 |
| **Child's birth order** | | | | | | | | |
| 1st born | 44 | 23 | 70 | 18 | 1.00 | | 1.00 | |
| 2nd–3rd born | 79 | 41 | 148 | 38 | 1.2 (0.74–1.9) | 0.491 | 0.6 (0.17–1.9) | 0.376 |
| ≥4$^{th}$ born | 70 | 36 | 168 | 44 | 1.5 (0.94–2.4) | 0.086 | 0.9 (0.26–2.9) | 0.809 |
| **HH size** | | | | | | | | |
| Small (2–4) | 64 | 33 | 74 | 19 | 1.00 | | 1.00 | |
| Large (5–9) | 108 | 56 | 263 | 68 | 2.1 (1.4–3.2) | <0.001* | 1.3 (0.44–3.9) | 0.639 |
| Very large (≥10) | 21 | 11 | 49 | 13 | 2.0 (1.1–3.7) | 0.024* | 0.9 (0.18–4.6) | 0.899 |
| **Child sex** | | | | | | | | |
| Female | 89 | 46 | 203 | 53 | 1.00 | | 1.00 | |
| Male | 104 | 54 | 183 | 47 | 0.8 (0.55–1.1) | 0.142 | 0.5 (0.22–1.2) | 0.115 |
| **Child had a comorbidity** | | | | | | | | |
| No | 162 | 84 | 377 | 98 | 1.00 | 1.00 | 1.00 | |
| Yes | 31 | 16 | 9 | 2 | 8.0 (3.7–17) | <0.001* | 12 (2.5–53) | 0.002* |
| **Household in settlement** | | | | | | | | |
| No | 15 | 8 | 49 | 13 | 1.00 | | 1.00 | |
| Yes | 178 | 92 | 337 | 87 | 0.6 (0.32–1.1) | 0.078 | 0.3 (0.04–2.1) | 0.218 |
| **Hand washing facility near toilet[†] (<2 m away)** | | | | | | | | |
| Yes | 23 | 51 | 45 | 34 | 1.00 | | 1.00 | |
| No | 22 | 49 | 86 | 66 | 2.0 (1.1–4) | 0.048* | 1.1 (0.48–2.7) | 0.776 |
| **Wash hands with soap after visiting the toilet** | | | | | | | | |
| Yes | 87 | 45 | 141 | 37 | 1.00 | | 1.00 | |
| No | 106 | 55 | 245 | 63 | 1.4 (1.1–2.0) | 0.048* | 3.9 (1.2–13) | 0.027* |
| **Main source of water** | | | | | | | | |
| Pipped | 114 | 59 | 160 | 41 | 1.00 | | 1.00 | |
| Borehole | 79 | 41 | 226 | 59 | 2.1 (1.4–2.9) | <0.001* | 4.0 (1.7–9.6) | 0.002* |

*Significant association at $p < 0.05$, [†]Among 45 cases and 131 controls that received rotavirus vaccine.

visiting the toilet, and AWD (Asfaha et al., 2018). 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, which was chlorinated. The chlorine in pipped water disinfects (kills) or inactivates diarrhea-causing organisms, hence rendering it safe for home use (Centres for Disease Control and Prevention, 2020). 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 (Basamba et al., 2013). Although boreholes and other ground water sources are classified as improved and safe water sources (UN World Water Development Report, 2022), several microbiological studies of groundwater sources, including boreholes, have reported high rates of *Escherichia coli,* indicating fecal contamination of those sources (Richardson et al., 2009; Kanyerere et al., 2012; Howard et al., 2003). 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 (Gundry et al., 2006). 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 (Hunter et al., 2013). 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 (Ssenyonga et al., 2009). 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 (Ssenyonga et al., 2009); 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.

## 5. 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. Additionally, there are difference between cases and controls on some variables such as nationality, child age, and household size, however measures were put in place to ensure collection of high-quality data during data collection.

## 6. Conclusion

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.

Ethics approval and consent to participate

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 (The National Institute for Occupational Safety and Health Institutional Review Board) and the Uganda Ministry of Health and were performed in accordance with the Declaration of Helsinki. Parental/legal guardian written informed consent was obtained on behalf of all the children before the start of each interview since they were aged less than 5 years. Written informed consent was also obtained from all study (caregivers/mothers) participants.

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Authors' contributions

EJN took the lead in conceptualizing the study idea, data collection, data analysis, writing, and editing of the manuscript. JK, LA, SMN, and RN were involved in data collection, data analysis, and writing of the manuscript. AK, FN, BK, LB, DK, PEO, and ARA were involved in the conceptualization of the study idea and the writing, editing, and reviewing of the manuscript. All authors read and approved the final manuscript.

## CRediT authorship contribution statement

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## References

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.

Angesom, T., 2015. Prevalence and associated factors of diarrhea among under-five children in laelay-Maychew District, Tigray region. Addis Ababa University, Ethiopia.

Arvelo, W., Kim, A., Creek, T., Legwaila, K., Puhr, N., Johnston, S., et al., 2010. 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. Int. J. Infect. Dis. 14 (11), e1002–e1007.

Asfaha, K.F., Tesfamichael, F.A., Fisseha, G.K., Misgina, K.H., Weldu, M.G., Welehaweria, N.B., et al., 2018. Determinants of childhood diarrhea in medebay Zana District, Northwest Tigray, Ethiopia: a community based unmatched case–control study. BMC Pediatr. 18 (1), 1–9.

Basamba, T.A., Sekabira, K., Kayombo, C.M., Ssegawa, P., 2013. Application of factor and cluster analyses in the assessment of sources of contaminants in borehole water in Tanzania. Pol. J. Environ. Stud. 22 (2), 337–346.

Budhathoki, S.S., Bhattachan, M., Yadav, A.K., Upadhyaya, P., Pokharel, P.K., 2016. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Tropical Medicine and Health. 44 (1), 1–7.

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.

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

Derseh, B., Mruts, K., Demie, T., Gebremariam, T., 2018. 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. Nutr. J. 17 (1), 116.

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.

Drugs and Diseases: Pediatrics: General Medicine: Diarrhea [Internet]. Medscape. 2020 [cited 7 November 2022]. Available from: https://emedicine.medscape.com/article/928598-overview.

Gashaw, T.A., Walie, Y.M., 2019. 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. 5 (1), 008–014.

Getachew, A., Guadu, T., Tadie, A., Gizaw, Z., Gebrehiwot, M., Cherkos, D.H., et al., 2018. Diarrhea prevalence and sociodemographic factors among under-five children in rural areas of North Gondar zone, Northwest Ethiopia. Int. J. Pediatr. 2018.

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

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.

Gundry, S.W., Wright, J.A., Conroy, R., Du Preez, M., Genthe, B., Moyo, S., et al., 2006. 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. 1 (2).

Gunsa, G.G., Rodamo, K.M., Dangiso, D.D., 2018. Determinants of acute diarrhoea among children aged 6–59 months in Chiffre District, southern Ethiopia: unmatched case-control study. J Gynecol Obstet. 6 (2), 15–25.

Hashi, A., Kumie, A., Gasana, J., 2017. 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. Prev. Med. Rep. 6, 361–368.

Howard, G., Pedley, S., Barrett, M., Nalubega, M., Johal, K., 2003. Risk factors contributing to microbiological contamination of shallow groundwater in Kampala. Uganda. Water Research. 37 (14), 3421–3429.

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

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.

Kabhele, S., New-Aaron, M., Kibusi, S.M., Gesase, A.P., 2018. Prevalence and factors associated with diarrhoea among children between 6 and 59 months of age in Mwanza city Tanzania. J. Trop. Pediatr. 64 (6), 523–530.

Kanyerere, T., Levy, J., Xu, Y., Saka, J., 2012. Assessment of microbial contamination of groundwater in upper Limphasa River catchment, located in a rural area of northern Malawi. Water SA 38 (4), 581–596.

Kasye, D.G., Garoma, N.H., Kassa, M.A., 2018. Assessment of the prevalence of diarrheal disease under-five children serbo town, Jimma zone south West Ethiopia. Clin Mother Child Health. 15 (281), 2.

Melese, B., Paulos, W., Astawesegn, F.H., Gelgelu, T.B., 2019. 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 19 (1), 1–10.

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.

MoH, 2021. National Technical Guidelines for integrated disease surveillance and response. third ed: ministry of. Health.

MoH, 2022. 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.

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.

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.

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

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

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.

Mulholland, K., 2005. Commentary: comorbidity as a factor in child health and child survival in developing countries. Int. J. Epidemiol. 34 (2), 375–377.

Musonda, C., Siziya, S., Kwangu, M., Mulenga, D., 2017. 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. 4 (3), 228–234.

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.

Nantege, R., Kajoba, D., Ddamulira, C., Ndoboli, F., Ndungutse, D., 2022. Prevalence and factors associated with diarrheal diseases among children below five years in selected slum settlements in Entebbe municipality. Wakiso District, Uganda.

Netsereab, T.B., Xenos, P., 2017. Factors associated with diarrhea among children less than 5 years old in Sudan. Journal of Health Research. 31 (Suppl. 2), S209–S215.

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

Richardson, H.Y., Nichols, G., Lane, C., Lake, I.R., Hunter, P.R., 2009. Microbiological surveillance of private water supplies in England-the impact of environmental and climate factors on water quality. Water Res. 43 (8), 2159–2168.

Sinmegn Mihrete, T., Asres Alemie, G., Shimeka, T.A., 2014. Determinants of childhood diarrhea among underfive children in benishangul gumuz regional state, north West Ethiopia. BMC Pediatr. 14 (1), 1–9.

Ssenyonga, R., Muwonge, R., Twebaze, F., Mutyabule, R., 2009. Determinants of acute diarrhoea in children aged 0–5 years in Uganda. East Afr. Med. J. 86 (11), 513–519.

Tamiso, A., Yitayal, M., Awoke, A., 2014. Prevalence and determinants of childhood diarrhoea among graduated households, in rural area of shebedino district, southern Ethiopia, 2013. Science 2 (3), 243–251.

Tesfaye, T.S., Magarsa, A.U., Zeleke, T.M., 2020. 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. 11, 437.

UBOS, 2017. National Population and Housing Census 2014: Area specific profiles-Moyo District. Uganda Bureau of Statistics (UBOS), Kampala.

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/.

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/.

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.

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.