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Determination of Factors that Contribute to the Prevalence of Diarrhoea among Children Under Five Years of Age in Association with the Status of Drinking Water Sources at Bububu, Zanzibar

Wahida M. Ali[1] and Emmanuel S. Kigadye*[2]
[1]*Zanzibar Food and Drug Agency, P.O. Box 3595 Zanzibar, Tanzania. E-mail: wahdamudi@gmail.com*
[*2]*Department of Life Science, Open University of Tanzania. P.O. Box 23409 Dar es Salaam, Tanzania. E-mail: emmanuel.kigadye@out.ac.tz*
Corresponding author.
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Abstract

This study aimed to determine the contributing factors for diarrhoea prevalence among children under-five years at Bububu, Zanzibar. The study applied a cross-sectional research design that used quantitative methods. Data were collected from 97 mothers/caregivers of the children. Structured questionnaires were used for assessing socio-economic factors contributing to diarrhoea. Laboratory experiments were carried out to assess the quality of drinking water sources. Most Probable Number (MPN) count per 100 ml was measured from drinking water sources. Multivariate logistic analysis was computed to assess independent factors of childhood diarrhoea. The prevalence of diarrhoea was significantly associated with; the caregiver's level of education, large family size, nature of toilet used, drinking water storage, drinking water sources, belief that water is safe, household waste disposal, poor storage of baby's food and washing hands with soap ($p < 0.05$). Pathogenic bacterial contamination was found to be high in borehole water sources and harvested rainwater compared to piped water sources ($p < 0.05$). Health education, drinking water treatment, improved sanitation and hygiene could have significant importance in the reduction of diarrhoea prevalence among under-five children in the study area.

Keywords: Prevalence of diarrhoea, Social-economic factors, Bacteriological contamination, Drinking water, Under-five children.

Introduction

Globally, diarrhoea is the second leading cause of death in children; about 1.7 billion cases of diarrhoea disease occurred in children under five years of age (WHO/UNICEF 2017). Around 1.8 billion people worldwide use unsafe sources of drinking water (Pal et al. 2018). High contamination of drinking water sources is the main cause of epidemic outbreaks and isolated water-borne diseases (Odonkor and Addo 2018). Globally, it has been estimated that around 37.7 million people are affected by water-borne diseases, and 1.5 million children die annually (Pal et al. 2018).

In developing countries, about 3 million children die every year due to diarrhoea caused by contaminated drinking water (WHO/UNICEF 2017). Diarrhoea remains the leading killer disease in Southern Asia and Sub-Saharan African countries and accounted for nine per cent of all under-five deaths in 2015 (WHO/UNICEF 2015). Estimated deaths due to diarrhoea in Tanzania were 23,900 in 2012 (WHO/UNICEF 2014). Poor health associated with the consumption of untreated drinking water at the household level is one of the most significant concerns (Mohamed et al. 2016). Diarrhoea is the leading cause of morbidity and mortality in children in the Zanzibar islands, and it remains to be one of the most important childhood public health problems (MoH 2018). Epidemiological data related to diarrhoea from Zanzibar Health Units showed increased diarrhoea-related morbidity among children in Zanzibar (HMS 2016).

According to a study done in Zanzibar by Vuai (2012), the quality of drinking water is very poor due to microbiological contamination. Bacteriological quality of drinking water has been associated with the risks of water-related diseases and is the major public health problem in rural communities of Zanzibar (Vuai 2012, Omar 2015). However, no study had been carried out that reported the association among social demographics, socio-economic factors, bacteriological quality of drinking water and the prevalence of diarrhoea in children under five years of age in Zanzibar.

The present study, therefore, aimed to determine the association of the above factors with diarrhoea prevalence among children under-five years of age. The findings of this study could be invaluable to the Ministry of Health, public health stakeholders, policymakers and other responsible institutions in their efforts to control diarrhoea, especially in children under five years of age in Zanzibar.

Methodology

Study area: The study was conducted in seven wards of Bububu area in Unguja Island West District. Health facilities in that area are Kibweni (KMKM) and Bububu Military Hospitals. Bububu area was selected because it is overpopulated (298,078,812), has poor settlement planning and shortage of water supply which leads residents to depend on other water sources such as rivers, private wells, streams and boreholes. Unguja Island is approximately 1,464 square kilometres. Unguja population is approximately 735,000 (URT 2012, https://www.statista.com/statistics/1219087/projected-population-of-zanzibar/). Unguja is located about 35 km off the coast of Dar-es-Salaam-Tanzania.

Study population: The study population included all under-five years' children living in Bububu constituency attending hospital seeking treatment for diarrhoea illness. The study population was estimated by using the formula of Charon and Biswas (2013).

Inclusion criteria: Children below five years of age, attending hospital seeking treatment and children whose caretakers lived in the study area for at least one year and were willing to participate in the interviews.

Exclusion criteria**:** Children above five years of age and those who are not residents of the study area. Children who attended hospital for treatment with other types of illnesses were excluded.

Study design: The study was a cross-sectional study which applied quantitative research methods through structured questionnaires on demographic and socio-economic data from March to May 2018. In addition, an experimental study that applied laboratory analysis of water samples was conducted to determine the microbiological quality of drinking water from the sources.

Sample size and sampling: The sample size was calculated using the following formula for estimation by Charan and Biswas (2013):

$$N = (Z1\text{-}\alpha)^{2} \times P(1\text{-}P)^{2}/E^{2}$$

where $N = (1.96)^2 \times 0.7\ (I\text{-}0.7)^2/\ (0.05)^2 = 96.8 \approx 97$ samples, and where $Z_{1-x} = Z_{0.95} = 1.96$ (This value of 1.96 is standard for confidence level of 95%): P = prevalence of diarrhoea obtained from previous study = 0.7 (70%) (Omar 2015): E = is the degree of cumulative = 5% = 0.05 and 1–α = 95% is the confidence interval. This provided a sample size of 97 children.

Water sampling: Children who satisfied the inclusion criteria at the hospital were followed to their households during the next week for an interview to assess risk factors that contributed to diarrhoea. In addition, drinking water samples were collected from the respondents' water sources. Fifteen (15) drinking water samples were collected per week. A total of 97 drinking water samples were collected during 6.5 weeks. About 400 ml were poured into a sterilized sample bottle (WHO 2017). Each household was recorded and given an identification number indicating the village and type of water sources. All samples were stored in an ice box soon after collection and transferred to the Zanzibar Food and Drug Agency (ZFDA) laboratory for bacteriological analysis.

Data collection tools: A checklist was used to collect primary data on the prevalence of diarrhoea in children under five years of age in the selected hospitals. Structured questionnaires were used to determine risk factors associated with the occurrence of diarrhoea. Laboratory experiments on drinking water samples were conducted to assess water quality.

Ethical consideration: Ministry of Health Zanzibar, through Zanzibar Health Research Institute (ZAHRI), provided ethical clearance for data collection. Informed consent was sought from the participants and the purpose of the study was explained. Moreover, all the information gathered was handled confidentially.

Laboratory analysis

Drinking water samples were collected and analysed to assess their quality. Parameters examined in samples were total coliforms, *E. coli*, *Shigella* spp and *Vibrio* species for all three sources (piped, boreholes and harvested rainwater). The water sampling procedure and method for bacteriological examination were done as per standard protocol and guidelines (WHO 2017).

Total coliform and E. coli: For identification of *E. coli* and total coliforms bacteria were isolated using the Most Probable Number (MPN) Multiple-Tube Fermentation Technique (WHO 2017). Ten sets of test tubes containing 10 ml of Lauryl Sulphate Tryptose Broth (LSTB) were arranged and diluted in a series of 10 ml, 1 ml and 0.1 ml. All test tubes were incorporated with Durham tubes for the detection of gas formation by Gram-negative coliforms and incubated with caps at 37 °C for 24 hrs for *E. coli* and 44.5 °C for 24 hrs. Then, one loop-full sample from positive test tubes was inoculated on 10 ml Brilliant Green Bile Broth (BGBB) test tubes and incubated at 44.5 °C for 24 hrs, gas formation in inverted Durham tubes and turbidity in the media confirmed the presence of total coliforms and MPN was recorded. The positive samples were inoculated on Endo agar by streaking and incubated at 37 °C for 24 hrs. Observation of a green metallic shine indicated the presence of *E. coli* and an identification test was done to confirm the bacteria (WHO 2017, Odonkor and Addo 2018).

Shigella spp: About 100 ml of drinking water samples were filtered using the membrane filtration method through a 0.45 µm membrane. The membrane filter was directly inserted into the conical flask containing 100 ml of Bile Peptone Water (BPW) and incubated for 24 hrs at 37 °C. Then, 0.1 ml of Bile Peptone Water (BPW) was transferred into 9 ml Rappaport Vassiliadis Soya (RVs) in test tubes and incubated for 24 hrs at 41 °C. Then, from RVs tubes were streaked on the surface of Xylose Lysine Deoxycholate (XLD) agar plates and incubated for 24 hrs at 37 °C. *Shigella* spp were identified by their characteristic appearance on xylose lysine deoxycholate agar (WHO 2017, Odonkor and Addo 2018).

Vibrio species: For *Vibrio parahaemolyticus,* drinking water samples were enriched in alkaline peptone water (APW) for 6 to 8 hours, then sub-cultured in thiosulfate citrate bile salts sucrose agar plates and incubated at 37 °C for 18 to 24 hrs. The isolates also underwent a series of biochemical tests and their identity was further confirmed by the commercial API 20 E test (WHO 2003).

Data management, processing and analysis: Data were checked, screened and cleaned using Epi info version 3.5.4 to minimize errors, and then transferred into IBMSPPS version 21 for further analysis. Descriptive analysis was performed to determine frequency and percentages. Logistic regression was performed using Crude and Adjusted Odds ratios (at 95% CI) to identify potential risk factors associated with diarrhoea for children below five years of age in the study area.

Results

Prevalence of diarrhoea for children under under-five years

A total of 97 children under the age of 5 years were included. The results showed that 60 (61.9%) of the caretakers reported diarrhoea and only 37 (38.1%) reported no diarrhoea among their children under five year of age. The prevalence was significantly associated with demographic and socio-economic factors, water-related factors, behaviour and hygiene factors, and environmental and sanitation factors at $p < 0.05$ as indicated in Tables 1- 4.

Table 1: Relationships between demographic and socio-economic factors, and diarrhoea prevalence

Factors		**Cases**	**Control**	**COR (95% CI)**	**p value**
Sex of caretakers					
Male		16 (26.7%)	8 (21.62%)	1.318 (0.50–3.48)	0.577
Female		44 (73.3%)	29 (78.38%)		
Age of caretakers					
<30 yrs		39 (65%)	19 (51.35%)	1.76 (0.25–1.31)	0.185
>30 yrs		21 (35%)	18 (48.65%)		
Sex of children					
Male		18 (30.00%)	23 (62.16%)	0.261 (0.11–0.62)	0.002*
Female		42 (70.00%)	14 (37.83%)		
Age of children					
1-12 months		13 (21.67%)	7 (18.92%)	1.185 (0.425–3.309)	0.745
13-59 months		47 (78.33%)	30 (81.08%)		
Caretaker relationships with children					
Mother		32 (53.33%)	24 (64.86%)	0.619 (0.58–1.27)	0.444
Others		28 (46.67%)	13 (35.13%)		
Marital status					
Married		40 (66.67%)	28 (75.67%)	0.64 (0.75–3.63)	0.216
Others		20 (33.33%)	9 (24.32%)		
Level of education					
Non formal		5 (8.33%)	14 (37.84%)	0.149 (1.49–6.55)	0.003*
Formal		55 (91.67%)	23 (62.16%)		
Household properties					
Radio:	Yes	34 (56.67%	26 (70.27%)	0.553 (0.23–1.32)	0.183
	No	26 (43.33%)	11 (29.73%)		
Electricity:	Yes	43 (71.67%)	30 (81.08%)	0.59 (0.10–0.78)	0.299
	No	17 (28.33%)	7 (18.91%)		
Refrigerator:	Yes	8 (13.33%)	13 (35.13%)	0.284 (0.10–0.78	0.014*
	No	52 (86.67%)	24 (64.86%)		
Type of energy					
Gas		2 (3.33%)	9 (24.32%)	0.107 (0.337–1.118)	0.111
Others		58 (96.67%)	28 (75.67%)		
Number of people living in a household					
>Seven		50 (83.33%)	6 (16.21%)	25.833 (8.54–78.14)	0.000*****
<Seven		10 (16.67%)	31(83.78%)		

*****Note: *Prevalence of diarrhoea is associated with the above demographic and socio-economic factors at $p < 0.05$.*

Demographic and socio-economic factors

Results indicated that the prevalence of diarrhoea was significantly associated with sex, education and the number of people living in a household ($p < 0.05$) (Table 1). Female children were more at risk than males. Children belonging to caretakers with non-formal education and households with more than seven people living in one house were more at risk. However, other factors; caretaker age, relationships, marital status, household properties and the type of energy used did not show any association with the prevalence of diarrhoea ($p > 0.05$) (Table 1).

Relationship between water-related factors and diarrhoea prevalence

The results indicated that water-related factors are statistically associated with the prevalence of diarrhoea (Table 2). Households which utilised pipe water sources and treated drinking water were less likely to suffer from diarrhoea outbreaks ($p < 0.05$).

Table 2: Water-related factors and prevalence of diarrhoea in the area

Factors	Cases	Control	COR (95% Cl)	p-value
Water sources				
Piped water	11 (18.33%)	21 (56.75%)	0.175 (0.073–0.419)	0.000*
Others	49 (81.67)	16 (43.24%)		
Do you believe that water from source is safe?				
Yes	57 (95.00%)	6 (16.21%)	98.167 (22.95–419.87)	0.000*
No	3 (5.00%)	31 (83.78%)		
Do you treat your drinking water?				
Yes	12 (20.00%)	31 (83.78%)	0.048 (0.016–0.142)	0.000*
No	48 (80.00%)	6 (16.21%)		
If no, why don't you treat drinking water?				
Cost	25 (41.67%)	32 (86.49%)	1.205 (0.676–28.88)	0.121
Others	35 (58.33%)	5 (13.51%)		
If yes, how do you treat your drinking water?				
Decantation	51 (85.00%)	5 (13.51%)	36.27	0.000*
Others	9 (15.00%)	32 (86.49%)		

*Note: *Prevalence of diarrhoea is associated with the above water-related factors at $p < 0.05$.*

Behaviour and hygiene factors associated with the prevalence of diarrhoea

Results showed that behaviour and hygiene practices are significantly associated with the prevalence of diarrhoea (Table 3). Households that practised; storage of their drinking water in pots with lids, washing hands after defecation and other activities, washing hands with soap before handling food and covering baby's food were at fewer risks of getting diarrhoea ($p < 0.05$).

Environmental and sanitation factors associated with the prevalence of diarrhoea

The findings on environmental and sanitation factors associated with the prevalence of diarrhoea are summarised in Table 4. The results indicated that households which practised utilization of flush toilets and reached waste-collecting services had few episodes of diarrhoea compared to those which did not ($p < 0.05$). The site of disposing of baby faeces was not significantly associated with the prevalence of diarrhoea ($p > 0.05$).

Table 3: Relationship between behaviours and hygiene practices to the prevalence of diarrhoea

Factors	Case	Control	COR (95% Cl)	p-value
Do you store your drinking water?				
Yes	37 (61.67%)	36 (97.30%)	0.045 (0.06–0.34)	0.003*
Sometimes	23 (38.33%)	1 (2.70%)		
Which container is used to store your drinking water?				
Pot with lid	43 (71.67%)	7 (18.91%)	10.84 (2.107–10.1)	0.000*
Others	17 (28.33%)	30 (81.08%)		
When do you wash your hands?				
After visiting toilets	4 (6.67%)	22 (59.46%)	0.048 (0.118–0.41)	0.000*
Others	56 (93.33%)	15 (4054%)		
Do you use soap when washing your hands?				
Yes	4 (6.67%)	25 (67.57%)	0.034 (0.009–0.55)	0.000*
No	56 (93.33%)	12 (32.43%)		
Do you cover your baby's food?				
Yes	43 (71.67%)	36 (97.30%)	0.070 (0.009–0.55)	0.012*
No	17 (28.33%)	1 (2.70%)		

*Note: *Prevalence of diarrhoea is associated with the above behaviour and hygiene factors at $p < 0.05$.*

Table 4: Environmental and sanitation factors related to the diarrhoea prevalence

Factors	Case	Control	COR (95% Cl)	p value
Type of toilet used				
Flush	8 (13.33%)	22 (59.46%)	0.104 (0.057–0.284)	0.000*
Others	52 (86.67%)	15 (40.54%)		
Where do you dispose of your baby's faeces?				
Left in house waste	51 (85.00%)	15 (40.54%)	8.31 (0.413–1.770)	0.672
In the toilet	9 (15.00%)	22 (59.46%)		
Where do you dispose of your household waste?				
Collecting services	4 (6.67%)	25 (67.57%)	0.034 (0.059–0.264)	0.000*
Others	56 (93.33%)	12 (32.43%)		

*****Note*: Prevalence of diarrhoea is associated with the above environmental and sanitation factors at $p < 0.05$.*

Knowledge and awareness factors among caretakers in the study area

Mothers who breastfed their children with supplementary food were more likely to get diarrhoea (p = 0.084) than those who breastfed their children without supplementary food (COR = 0.07, p = 0.034). The practice of washing hands before handling supplementary food did not show statistical significance (p = 0.740) in association with the prevalence of diarrhoea.

Multivariate logistic regression analysis of independent variables

This was carried out by including all factors that had a $p < 0.05$ in bivariate analysis to determine the Adjusted Odds Ratios (AOR). The confounding variables were then used to find out the risk factors which were significantly associated with the prevalence of diarrhoea disease for children under five years of age and the results indicated that 10 factors were statistically associated with the prevalence of diarrhoea in the studied children (Appendix 1).

Bacteriological quality of drinking water sources in the study area

Results indicate that boreholes were contaminated by total coliforms (72.41%) followed by *E. coli* (65.52%), *Vibrio Parahaemolyticus* (34.48%) and *Shigella* spp. (27.58%). In piped water, total coliforms (53.12%) were more prevalent followed by *E. coli* (43.75%), *Vibrio parahaemolyticus* (25.0%) and *Shigella* spp. (6.25%). In harvested rainwater, *E. coli* (100%) dominated followed by total coliforms (100%), *Shigella* spp (28.57%) and *Vibrio Parahaemolyticus* (0%). Taking the average in terms of percentages of contamination, it can be concluded that harvested rainwater was more contaminated at 57%, followed by boreholes water (50%) and piped water (32%) ($p < 0.005$) (Table 5).

Table 5: Bacteriological quality of drinking water sources

Water Source	Percentage contamination (%)				Average (%)
	Total coliforms	*E. coli*	*Shigella* spp.	*V. Parahaemolyticus*	
Bore-hole	72.41	65.52	27.58	34.48	50
Pipe-water	53.12	43.75	6.25	25.0	32
Rain water	100	100	28.57	0	57

Moreover, the findings indicate that only 19 (32.75%) samples from boreholes and 16 (50.00%) samples from piped water had an acceptable limit as per the World Health Organization’s (WHO) Guidelines for drinking-water quality (GDWQ) (WHO 2017) (Figure 1).

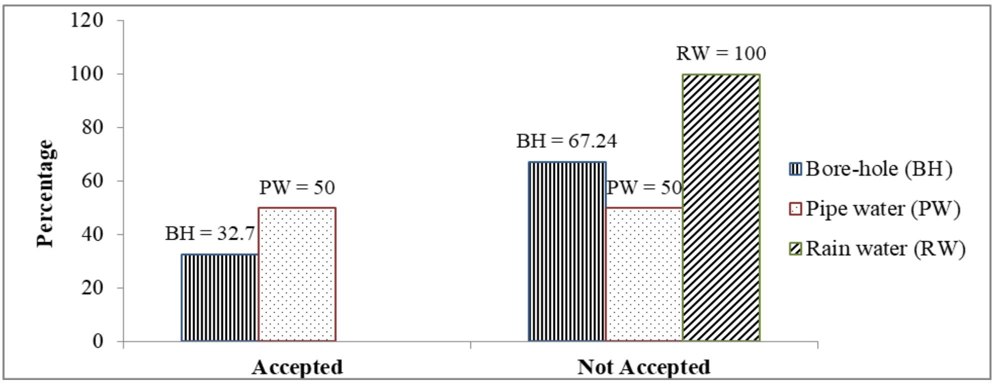

Figure 1: General safety of drinking water sources during the rainy season.

Discussion

Socio-demographic and economic factors contribution to diarrhoea prevalence

The findings of the present study indicated that several demographic and socio-economic factors such as the sex of children, caretakers' level of education and number of people living in the household influence the prevalence of diarrhoea in children under five years of age in the study area. The present study reported that diarrhoea prevalence was higher in females compared to male children. This finding is in agreement with the findings of studies in Sub-Sahara Africa by Ayuk et al. (2018) and South India by Majumder et al. (2017) who reported that female children had a high prevalence of diarrhoea than males. Also, a study done in Ghana by Tetteh et al. (2018) reported similar findings. On another hand, Siziya et al. (2013) reported that boys were more affected than girls, and Hamangaba (2016) observed that sex did not influence the prevalence of diarrhoea. These differences may be attributed to cultural influences and the differences in methodological approaches of the studies

(Tetteh et al. 2018). It has been reported that gender variations in infectious diseases like diarrhoea may reflect differences in gender norms (Thiam et al. 2017). Further studies are needed to explain clearly the observed gender variations in diarrhoea prevalence among under-five years of age children in the study area.

In the present study, it was found that children belonging to caretakers with non-formal education were three times more likely to have diarrhoea compared to those with formal education. This may be attributed to high levels of awareness among urban area residents since most of these study participants were literate. Another possible explanation is the outcome of the Afya Bora Project that provided community knowledge on Water, Sanitation and Hygiene (WASH) through community health care workers from 2015 to 2019 in Zanzibar (UNICEF, UNFPA 2020).

Education has a greater impact on changing the behaviour at the household level and can bring better knowledge about good hygienic practices. In addition, the level of education can lead to appropriate child feeding practices and an understanding of major determinants for the occurrence of diarrhoea diseases (Alebel et al. 2018). Several studies have also reported similar findings (Chilambwe et al. 2015, Hashi et al. 2016, Alebel et al. 2018).

According to a study conducted in Southern Ethiopia by Godanaand Mengistie (2013), the large family size was found to be associated with the prevalence of diarrhoea in the community, a fact that supports the findings of the present study. Again, this finding concurs with a study conducted in Dar es Salaam Tanzania by Sembua (2017) which showed that children living in large family sizes have a large chance of contracting diarrhoea compared to children living within small family size setups. It has been reported that large families increase the number of persons who visit drinking water sources, thus increasing the probability of contaminating the sources and increasing the risks of diarrhoea (Tambe et al. 2015). This observation applies to the findings of the present study since most households were found to have large families that mainly depend on contaminated water from boreholes.

Water-related factors contributing to diarrhoea

In this study, drinking water sources were associated with diarrhoea prevalence. It was found that households accessing piped water were less likely to get diarrhoea diseases compared to those using other sources of drinking water. Similar findings have been reported by Beyene et al. (2018) in Ethiopia and Ayuk et al. (2018) in Cameroon. Poor accessibility of safe drinking water and a majority of residents depending on untreated drinking water sources (borehole and rainwater) which are contaminated by pathogenic bacteria, especially during the rainy season could be the main reasons for the high prevalence of diarrhoea outbreaks in children under five years of age in the study area. The findings of this study suggest that efforts to reduce childhood diarrhoea morbidity would be greatly enhanced by strengthening piped water access in the study area.

The belief that water is safe from the sources

Another important finding of the present study is that respondents, who believed that water collected from the source without treatment is safe, were more likely to report diarrhoea incidences. This finding is in agreement with the study conducted in Tanzania by Kakulu (2012). The possible reason for this finding is that majority of residents (90.48%) do not treat their drinking water because they believe that the water provided is safe from the sources. These beliefs contribute greatly to the high prevalence of diarrhoea disease in children under five years of age in the study area. Change in community attitudes towards water treatment practices is necessary to reduce diarrhoea incidences in children under-five years of age.

Behaviour and hygiene factors contribute to diarrhoea

The findings of the present study indicate that poorly stored drinking water at the household level was associated with diarrhoeal diseases among children under five years of age. It was found that households using uncovered water containers and lacking hand washing setups were more likely to report children with diarrhoea. Beyene et al. (2018) and Mekonnen et al. (2019) reported similar findings in Ethiopia. These studies observed that microbiological contamination of water was higher at household levels than at primary sources due to poor water storage and unhygienic practices in households. Moreover, a study done in Nigeria by Hussein (2017) showed that in households using unimproved sources including unprotected well, their children were more prone to diarrhoea episodes. It has been observed that microbial quality of drinking water at the household level can be improved by treating drinking water, safe storage and short time storage; these can reduce diarrhoea and other water-borne diseases in communities (Ercumen et al. 2015, Packiyam et al. 2016, Yared 2016, Moropeng et al. 2018, Beyene et al. 2018). In addition, washing hands with soap and covering the baby’s food have a positive impact on the reduction of diarrhoea episodes in households (Sembua 2017, Alebel et al. 2018). In the present study, it was also found that caretakers who wash hands with soap, their children were less likely to get diarrhoea compared to the children whose caretakers do not wash their hands with soap. Moreover, in this study, it was found that storage of a baby’s food on an open shelf or the table is an unsafe practice because this can only prevent flies but not vectors such as cockroaches that are responsible for transmitting pathogens. Households should be sensitized to treat their drinking water, wash hands with soap, and store drinking water in containers with cover should be provided to reduce the under-five diarrhoea in the study area.

Environmental and sanitation factors contributing to diarrhoea

Mohammed and Zungu (2016) in Southern Ethiopia reported that the type of toilet used by households was associated with the prevalence of diarrhoea. Likewise, in this study, it was found that type of toilet used was associated with diarrhoea prevalence. Households that use the flush toilet (improved toilets) their children were less likely to get diarrhoea compared to those who use other types of toilets (unimproved toilets). The findings of this study concur with Ayele et al. (2014) in Senegal and Thiam et al. (2017) in Ethiopia, who argued that improved toilets are very important factors for diarrhoea control and prevention. In addition, unavailability of latrine and poor latrine (unimproved) can influence diarrhoea prevalence because they can lead to bacteria transmission and increase the risks of diarrhoea for children under five years of age (Sembua 2017).

Nevertheless, indiscriminate disposal of solid waste was significantly associated with a high rate of diarrhoea. Zanzibar municipality faces challenges in picking waste produced from each house due to financial and infrastructure limitations, because residents cannot afford to pay waste collection fees to private collectors. This results in the majority of households disposing of their house waste in the streets (open spaces). This study adds further support to the importance of sanitation improvements in Zanzibar municipality.

Levels of bacteriological contamination of drinking water sources

The findings of the present study showed that drinking water sources in the study area were contaminated with pathogenic bacteria. Contamination was found to be high in borehole water sources and harvested rainwater compared to tap water sources. Total coliforms and *E. coli* analysis were found to dominate in boreholes water sources followed by *Shigella* spp and *V. parahaemolyticus*. These findings are supported by studies conducted by Imade and Eghafona (2015) in Benin City and Akinola et al. (2018) in Iwo Osun State in Nigeria. However, the results do not concur with those of Kimani (2013) who reported that contamination of drinking water was recorded more in public/tap water than in household water sources in Kasarani, Nairobi City Kenya. Moreover, the findings showed that the majority (62.9%) of water samples obtained from boreholes were within the unacceptable limit as per WHO guidelines for drinking water quality standards (WHO 2017). This could be explained by the fact that during the rainy season, flowing water contaminates bore-hole water sources. A similar observation has also been reported by Kulinkina et al. (2016) in South India and Omar (2015) in Zanzibar.

The findings of the present study indicated that low bacterial contamination was found in pipe water sources. Pipe water is less contaminated compared to other sources of water because water is transferred through pipes and is usually treated from the main sources (Shields et al. 2015). Again, a study conducted in Indonesia by Komarulzaman et al. (2017) concluded that pipe water sources reduce the burden of diarrhoea disease in the communities. In that study, it was found that the majority of harvested rainwater samples had an unacceptable limit for drinking water quality standards. Bain et al. (2014) observed that most of the rainwater samples are contaminated by bacteria. In the present study, the faecal contamination in rainwater samples is probably due to birds and small animals dropping their faeces from the roofs. Therefore, the present study reports that there is a significant association between the bacteriological contamination of drinking water and diarrhoea prevalence. The results indicate that the majority of respondents in the study area used drinking water with an unacceptable limit of bacteriological contamination.

Conclusion and recommendations

Childhood diarrhoea remains the commonest health problem in Bububu, Unguja. The findings have important policy implications for childhood diarrhoeal disease intervention programmes. Thus, activities focusing on proper hand washing techniques at all appropriate times, drinking water storage, proper refuse disposal, covering baby's food, using a suitable toilet, improving sanitation and treating drinking water, are highly recommended. In addition, health education should be provided to reduce the under-five years of age diarrhoea in the study area.

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Appendix 1: Multivariate logistic analysis for the risk factors in the study area

Risk factors	AOR	95% CI	p value
Sex of children			
Female	0.174	0.015–0.377	0.034*
Male	1		
Level of education			
Non formal	0.236	0.053–0.304	0.006*
Formal	1		
Use of refrigerator			
No	-0.035	-0.041–0.701	0.697
Yes	1		
Number of people living in a household			
>Seven	0.593	0.426–0.739	0.000*
<Seven	1		
Main source of drinking water			
Other sources	-0.360	-0.30–0.037	0.013*
Piped water	1		
Do you believe that water provided from the source is safe?			
Yes	0.33	0.110–0.816	0.011*
No	1		
Do you treat your drinking water?			
No	0.080	-0.197–0.381	0.526
Yes	1		
If no, why not treating your drinking water?			
Others	0.245	-0.016–0.234	0.086
Cost	1		
If ye, how do you treat your drinking water?			
Decantation	0.107	-0.340–0.754	0.450
Other methods	1		
Do you store your drinking water?			
No	-0.262	-0.501–0.88	0.006*
Yes	1		
Container normally used to store drinking water			
Pot with lid	0.046	-110–0.180	0.628
Others	1		
When do you wash your hands?			
Others	0.099	-0.178–0.062	0.340
After toilet	1		
Do you use soap when washing your hands?			
No	-0.409	- (0.651–0.218)	0.000*
Yes	1		
Do you cover your baby's food?			
No	-0.219	-0.481–0.068	0.010*
Yes	1		
What type of toilet does your household normally use?			
Others	-0.292	- (0.203–0.010)	0.030*
Flash	1		
How do you dispose household wastes?			
Others	-0.305	- (0.253–0.019)	0.023*
Collected by private	1		
Is your child breastfed and provided with supplementary food?			
Yes	0.015	-0.302–0.366	0.850
No	1		