EAHRC
EAST AFRICAN HEALTH RESEARCH COMMISSION
Research for Health and Prosperity

ORIGINAL ARTICLE

Hygiene Practices, Water Supply, Sanitation, and Childhood Diarrhoea in Resource-Poor Settings of Rural Central Tanzania: A Mixed-Method Study

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ABSTRACT

Diarrhoeal diseases are associated with high morbidity and mortality, especially in children less than five years of age in many low- and middle-income countries (LMICs). This cross-sectional convergence mixed-method study explored water, sanitation and hygiene challenges as the important contributors to childhood diarrhoea in rural Tanzania. The study involved questionnaire survey (N=340), key informant interviews (KII) (n=10) and eight focus group discussions (FDG) (n=61). Prevalence of diarrhoea was 22.2% and 18.7% in Sanza and Iwondo Wards, of Manyoni and Mpwapwa Districts respectively. Improved houses (iron roof and baked brick walls) were more common in Sanza, while 80% of the houses in both wards had earth floor. Water sources in dry period and frequency of sharing water sources with animal were significantly different between wards ($P<.001$). Boiling drinking water was uncommon, practised by only 5.2% and 8.6% of the households in Sanza and Iwondo, respectively. More than 95% of the households in both wards used traditional pit latrines, and latrine sharing was more common in Iwondo than in Sanza ($P=.035$). The themes from KII and FGD were: knowledge of occurrence and causes of diarrhoea, water safety, hand-washing, availability of improved sanitation services, keeping chickens inside the house overnight, health effects associated with keeping chickens inside the house and knowledge of occurrence and causes of diarrhoea. Mixed methods analysis through merging data sets revealed poor community knowledge on the causes of childhood diarrhoea, ineffective hand washing, seasonal variation of drinking water sources and high human-chicken interactions. Prevention and control of gastrointestinal infections in resource-poor settings should promote the use of cheap and locally available resources and feasible practices in response to the existing challenges related to water and sanitation services, financial constraints, economic activities, and cultural practices.

BACKGROUND

Good hygiene practices, sanitary services, and a reliable and safe water supply are key elements in reducing the impact of gastrointestinal infection in a community. Global data indicate that in 2015, out of 159 million people depending on surface sources for drinking water, 58% were from sub-Saharan Africa.[1] Unsafe drinking water, poor sanitation and lack of hygiene contributed to about 870,000 deaths in 2016 worldwide, mainly as a result of diarrhoeal diseases, malnutrition and intestinal nematode infections.[1] In Tanzania, 13.8% of urban households and 52.2% of rural households depend on untreated water sources.[2] Despite the differences in safe water availability, the prevalence of diarrhoea in children aged between 6 and 11 months in urban communities (14.1%) differs little from that seen in rural areas (11%) of Tanzania.[2]

Poor hygiene practices can lead to contamination of food by gastrointestinal pathogens. Washing hands at critical intervals, including before eating, before feeding children, after cleaning children following defaecation, before food preparation and after using the latrine reduce the incidence of diarrhoea in children.[3] Affordability of clean water is a key factor forcing households in rural Tanzania to use highly contaminated and distant water sources that are free of charge.[4] Home water treatment through boiling or using chemicals is generally recommended, but most households do not treat drinking water.[5] Repeated gastrointestinal infections in children occur as a result of consumption of contaminated food and water and

mouthing contaminated objects and resulting in malabsorption of nutrients and undernutrition.[6]

Improvement in sanitary services and use of improved water sources are sometimes challenging to implement in rural areas of low- and middle-income countries (LMIC) mostly due to household financial reasons.[7,8] Some households continue to practise open defaecation or share one latrine between several households.[5] Children under five years of age from households lacking an improved water supply, access to sanitation facilities and sanitary disposal of faeces have a high risk of developing diarrhoea, fever and coughing.[9] House construction can impact household hygiene practices. Earth or sand floors cannot be adequately cleaned compared to cement floors and have been reported to be significantly associated with diarrhoea in children.[10] Houses and compounds shared with domestic animals and harbouring pests, such as rats, can also be the source of contamination of utensils and the household compound with animal faeces.[11,12] In Tanzania however, there are few studies conducted in rural resource-poor settings to indicate the status of the water, sanitation and hygiene. Therefore, this study aimed to identify deficiencies in hygiene practices, sanitation, availability of water services and occurrence of diarrhoea, and community knowledge of the causes of diarrhoea. Ultimately the study aimed to identify manageable areas to prioritise in devising community-based interventions to reduce childhood diarrhoea and its impact. It is envisaged that the results of the current study will assist the policy-makers in devising appropriate interventions specific to these areas by considering locally available resources.

MATERIALS AND METHODS

Study Area

The cross-sectional convergence mixed-method study was used to explored water, sanitation and hygiene challenges in Sanza and Iwondo Wards, of the Manyoni and Mpwapwa Districts, respectively. Both wards are found in the Great Rift Valley and are among areas that form the semi-arid zone of central Tanzania. The number of households in the Sanza and Iwondo Wards was 1,730 and 2,004 respectively, based on the census conducted in May 2014 in Sanza and December 2016 in Iwondo, within the project titled 'Strengthening food and nutrition security through family poultry and crop integration in Tanzania and Zambia (Nkuku4U project)[13]

These areas are characterised by low, short and often erratic rainfall of about 600 mm per annum in a unimodal pattern, from November to April.[14] Due to low and sometimes unpredictable rainfall, these areas frequently face food and water shortages and mostly depend on surface water sources which await rainfall for refilling. Keeping scavenging indigenous chickens is a common activity practised by more than half of the households throughout the year.[15] Scavenging indigenous chickens are the livestock least affected by the dry season and unpredictable climatic conditions affecting feed and water availability.[16] This study does not claim these sites to be a representative of communities in Central Tanzania rather, the study was implemented in collaboration with a larger project and the findings reflect the situation in the studied community.

Quantitative Data Collection

This study was conducted in association with a broader cluster randomised control trial study of a food and nutrition security project (Nkuku4U project).[13] The project was implemented in central Tanzania and Zambia as five-year cluster-randomised controlled trial to reduce childhood undernutrition by strengthening household nutrition through improving poultry and crop integration systems. The project collected reports of the incidence of diarrhoea in children under five years of age, but there was limited information collected on safe water supply, hygiene, sanitation and human-animal interactions. The current study was implemented to address the information gaps about water, sanitation, hygiene and human-animal interactions. These elements are important in determining the occurrence of diarrhoea in children, which in turn may have acted as a confounding factors to the Nkuku4U intervention outcomes.

The calculation of the overall sample size used by the Nkuku4U study was based on an estimated baseline stunting prevalence of 35%, aiming at achieving a 10% point reduction at the end of the project, and giving 80% power to detect this difference as being significant at the two-sided 5% level, assuming an intra-cluster correlation coefficient of 0.014.[16] The project census across the two wards was conducted by trained male and female enumerators recruited from both wards. All households within reach by foot, motorbike or vehicle were visited by trained enumerators to collect information on age and sex of household members, current ownership of village chickens and intention of chicken-keeping in the near future. A sampling frame was generated from all households with at least one child under two years of age during the census, keeping chickens or intending to keep chickens and intending to remain in the study areas for at least the next five years.

Two stage sampling was used to first enrol all eligible households with children under 12 months of age and then enrol additional households with children aged 12–24 months by random selection through a lottery draw using household identification numbers to give the required number of children. The numbers of children enrolled were 240 and 300 for Sanza and Iwondo Wards, respectively. The number of children in Iwondo were increased to offset the drop-out effect as was previously observed in the Sanza Ward. This occurred because of household members moving outside the study area, death of a child and household decisions to terminate participation. The younger child was enrolled from the households with more than one eligible child, and for twins random sampling through a lottery draw was employed to select one child.

Households participating in the current study were a subset of households participating in the larger project (Nkuku4U project), encompassing all households either currently owning chickens or owned chickens within the six months prior to questionnaire administration. A total of 340 (153 and 187 from Sanza and Iwondo, respectively) out of 532 households participating in the larger project during data collection fulfilled this criterion, and were all included in the present study. A cross-sectional questionnaire survey was conducted to 340 mothers or caregivers of participating households,

in February 2018. The questionnaire was pre-tested by first administering to a number of households from the study area, the areas of the questionnaires with ambiguities or lacking clarity were identified, and correction made before the survey commenced. The questionnaire was administered face-to-face through traditional paper and pencil interviews by trained male and female enumerators recruited from each ward. Survey questions were written in Swahili, but enumerators were encouraged to make use of the two predominant language groups (Gogo and Sukuma). Each questionnaire was close-checked by the supervisor (research team member) for completeness and correctness before being included in study. In case there was any skipped question or an ambiguity, the enumerator revisited the household alone or with supervisor depending the complexity of the deficit identified. The information collected by the questionnaire were related to childhood diarrhoea, housing, seasonal water supply, hand washing practices, water treatment, sanitary infrastructure availability and uses and human-chicken interactions.

Qualitative Data Collection

Cross-sectional FGDs and KIIs were conducted to collect qualitative data in the same wards (Sanza and Iwondo). The FGDs involved gender-disaggregated participants of the different socio-economic status. The socioeconomic status existing in communities (very rich, rich, poor and very poor) and inclusion criteria was determined through conducting a preliminary FGD comprising elders, social workers and community leaders. Establishing socioeconomic status was based on possession of properties, number of cattle owned, area of land cultivated (acres), year round food security and possession of a bank account. The established study FGD groups were Very rich male, Rich female, Poor male, Very poor female, Rich male, Very rich female, Very poor male and Poor female formed by combining the language group, socioeconomic status and gender. The current study conducted eight FGDs, one male and one female group from each of the four social groups comprising a total of 32 and 29 men and women, respectively under moderation of the lead author. Selection of participants was accomplished by the assistance of the community leaders based on stipulated inclusion criteria. Each FGD comprised seven to nine participants with a mean of eight participants, and each discussion was guided by a semi-structured questionnaire in Swahili or on-the-spot translation to indigenous languages if the need arose (appropriate translation into indigenous languages constituted part of enumerator training). Key informant interviews were conducted by the lead author on one-to-one basis with selected informants including the health workers, community workers, community leaders and traditional healer. All discussions during the FGDs and KIIs were detailed in notebooks by lead author and audio recorded by electronic tablet (Apple iPAD Model MD523X/A) operated by another research team member.

Data Analysis

Quantitative data were first entered in Microsoft Excel 2007 spreadsheets, saved as Stata files (STATA® version 14.2) and then imported to R studio software (R version 3.6.0) for analysis.[17] Proportions were used to present categorical variables and means and 95% confidence intervals were used to explore quantitative variables. The *t*-test was used to determine differences in means, and the chi-square test was used for evaluating differences in proportions for categorical variables between wards. Fisher's exact test was used for categorical variables with low expected frequencies (i.e. <5). The differences were considered significant at $p \leq 0.05$. The recorded KIIs and FGDs were translated from Swahili into English, transcribed and stored as Microsoft Word documents by lead author (Microsoft Word Office 2007). The saved translations were cross-checked against audio recordings by another research team member for correct translation and inclusion of all information. The draft code list was prepared by reading the transcript followed by the preparation of the final code list, and then transcripts were manually coded accordingly by the lead author supported by research team anthropologist using tools from the grounded theory approach.[18] Study themes were derived from data related to the research questions, then iteratively reviewed and revised through constant comparative analysis during the process of coding. The final themes that emerged were categorised into housing, water supply, hygiene, sanitation, human-animal interactions and knowledge of occurrence and causes of diarrhoea in children. The qualitative and quantitative data were linked in the analysis to aid the interpretation of the results obtained by the study. The key areas presenting the supporting and diverging results on specific areas in both quantitative and qualitative data sets were identified and interpreted to gain further understanding of the questionnaire responses and themes that emerged from the qualitative data. The study design, procedures, type of data collected, and data analysis are illustrated in Figure 1.

Ethical Considerations

Study design, protocols and research tools used by this study were approved by the Tanzanian National Institute for Medical Research (NIMR) ethics committee and the University of Sydney's Human Research Ethics Committee (approval number 2014/209). The informed consent forms were clearly read and the persons willing to participate in the study signed or thumb printed the form before commencing data collection exercise.

RESULTS

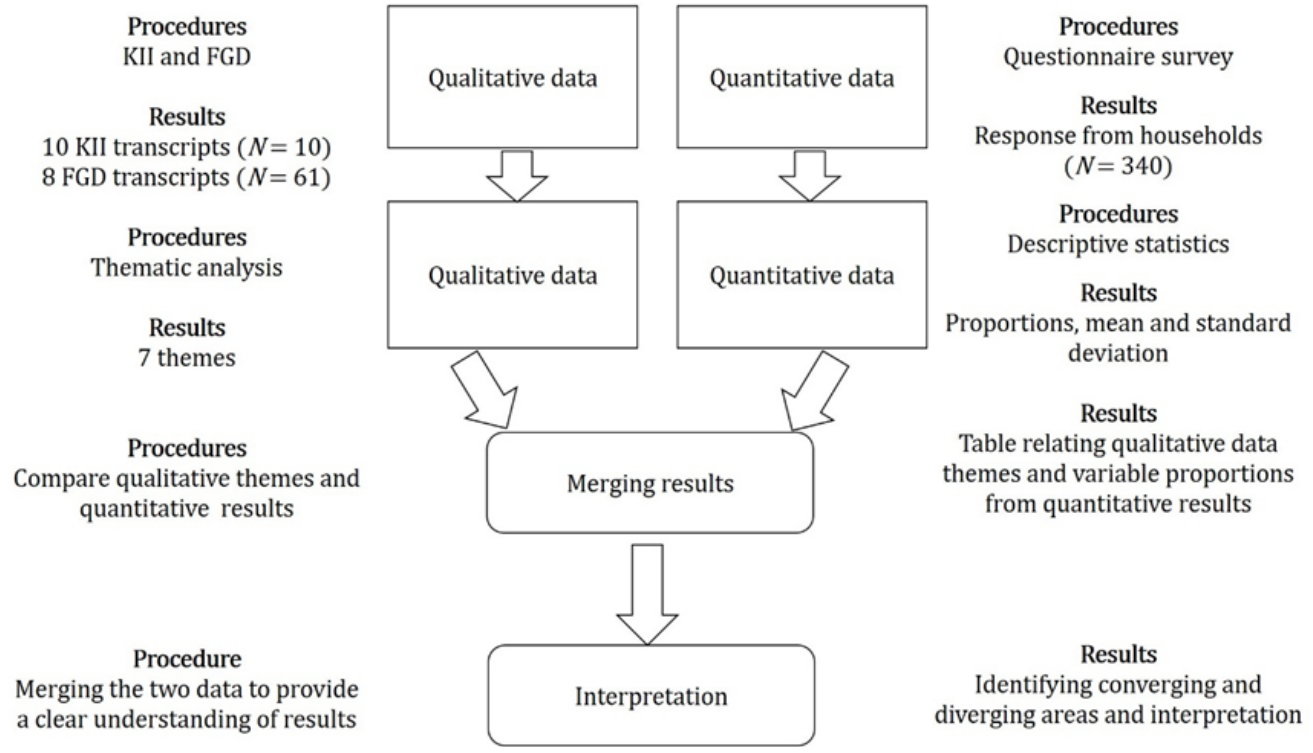
Socio-Demographic Characteristics

The mean age of respondents in Sanza and Iwondo was 33.9, (95% CI = 32.6–35.1) and 30.9 (95% CI = 29.9–32.0), respectively. The proportion of participants with schooling above primary school in Sanza (9.8%) was greater than in Iwondo (1.1%). In both wards, male-headed households were predominant, and the proportion of female-headed households in Sanza was almost twice (25.5%) that of Iwondo (13.4%) (Table 1).

Occurrence and Causes of Diarrhoea

Prevalence of children diarrhoea in the 30 days preceding the day of the questionnaire survey was 22.2% and 18.7% amongst children in Sanza and Iwondo Wards, respectively, and the difference between the wards was not significant (*P*=.50). Most of the FGD participants reported observing a high frequency of diarrhoea in

FIGURE 1: Mixed Methods Study Design of the House, Water, Hygiene, and Sanitation of Rural Households in Central Tanzania. Modified from reference[16]



children during the rainy season, and associated high incidences of diarrhoea with the use of pond water and eating fresh foods from the farm. Complementary feeding period was mentioned by the survey respondents and FGD participants as the stage most associated with high diarrhoea prevalence in children under five years of age (Table 2). The majority of households (>70%) in both wards perceived children under five years of age to be the age group most prone to diarrhoea; however, significant differences in perceptions about other age groups were seen between wards (<.001).

Among the proposed list of possible causes of diarrhoea in children under five years of age in the questionnaire survey, growth stages (44.4%) especially complementary feeding period were frequently mentioned by the respondents as the most important cause of diarrhoea (Table 2). The mixing of milk and solid foods in a child's stomach during complementary feeding was believed to be the cause of the problem as mentioned by KII and FGD participants. A small proportion of KII and FGD participants mentioned serving cold food and insufficient washing of utensils as the main reasons for an increase in diarrhoea frequency during complementary feeding, as mentioned by Health Volunteer Worker KII participant. '*Diarrhoea is mostly observed during complementary feeding because of inappropriate food preparation and handling, by feeding the children with cold food and allowing the flies and chickens to have access to children's food and the utensils*' (KII, Health Volunteer Worker) (Table 2).

Housing Condition and Cleaning

An unimproved house in the context of the study areas is one with a grass and mud roof, walls made from poles and mud or sun-dried bricks, and an earth or sand floor. Improved houses are those with an iron sheet roof, walls made from baked bricks or cement bricks, and at least a cement floor. Iron sheet roofing were more common in Sanza (41.2%) than in Iwondo (24.6%), *P*=.002, just as the number of baked earth or cement brick-walled houses was higher in Sanza (34.0%), than in Iwondo (10.7%), *P*<.001.

In both wards, 80% of the houses had earth floor, (Table 4). Earth floor was reported as a hindrance to sufficient cleaning of the house, as summarised by one FGD participant: '*The house with a cement floor is easier to clean - you can use even water and soap to mop, which cannot be done on an earth floor*' (FGD, Very poor male), (Table 5). The common types of waste encountered during cleaning the house mentioned by KII and FGD participants were faeces from children, chickens, rats, bats or owls, crop remains, food particles, small insects, dust and sand.

TABLE 1: Socio-Demographic Characteristics of the Study Population in Sanza and Iwondo Wards

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Age of respondents (years)				<.001
Mean (95% CI)	33.9 (32.6-35.1)	30.9 (29.9-31.9)	32.2 (31.4-33.0)	
Range	18-56	18-53	18-56	
Number of children under 5 years in the household				.002
Mean (95% CI)	1.7 (1.6-1.9)	1.5 (1.4-1.6)	1.6 (1.5-1.7)	
Range	1-4	1-4	1-4	
Highest level of formal education of mother (%)				<.001
Primary school	75.8	71.7	73.5	
Above primary school	9.8	1.1	5.0	
None	14.4	27.3	21.5	
Sex of head of household (%)				.005
Male	74.5	86.6	81.2	
Female	25.5	13.4	18.8	

TABLE 2: . Occurrence and Perceived Self-Reported Causes of Diarrhoea

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Households reported diarrhoea cases (s) in 30 days preceding questionnaire administration (%)				.498
Children with diarrhoea	22.2	18.7	20.3	
Children without diarrhoea	77.8	81.3	79.7	
The age group reported being most commonly experiencing diarrhoea (%)				<.001
Children under five years of age	72.6	80.8	77.1	
Children above five years of age	4.6	1.6	2.9	
Adults over 18 years of age	2.0	0.0	0.9	
No difference	17.7	6.4	11.5	
Don't know	3.3	11.2	7.6	
Growth stage frequently affected by diarrhoea, amongst children under five years of age (%)				<.001
Exclusive breastfeeding stage	16.5	15.5	15.9	
Complementary feeding stage	38.8	44.4	41.9	
Weaning stage	7.9	12.3	10.3	
All stages are the same	34.2	16.0	24.2	
Don't know	2.6	11.8	7.7	
Reported causes of diarrhoea (multiple responses possible) (%)				
Unhygienic food handling	18.9	27.8	23.8	
Drinking unsafe water	30.7	20.3	25.0	
Poor cleaning of utensils	2.6	4.8	3.8	
Unhygienic environment	32.0	25.1	28.2	
Partially cooked food	20.2	4.8	11.8	
Dirty house	0.0	3.2	1.7	
Staying with animals in the same house	2.0	4.3	3.2	
Sharing the utensils with chickens	2.6	10.7	7.1	
Eating without washing hands	12.4	26.7	20.3	
Washing hands in a communal bowl	1.3	12.3	7.4	
Not using toilet	2.0	6.4	4.4	
Growth stage	35.3	51.9	44.4	
Evil actions	0.0	5.9	3.2	
Don't know	1.3	4.3	2.9	

Water Sources, Water Treatment and Seasonal Variations in Water Access

During the dry season, the primary source of drinking water was open wells in Sanza (79.1%) and public taps in Iwondo (65.2%), and the difference in sourcing drinking water between wards was significant (P<.001) (Table 6). During the rainy season, most households in Sanza (74.5%) and Iwondo (79.1%) used a stream, river, pond or dam as their main source of drinking water. In Iwondo, tap water was frequently used in the dry season because other sources had no water and in the rainy season, surface water was mostly used as it was convenient, plentiful and free of charge. This was further confirmed by Traditional Healer KII participant: '*During the rainy season, we cut the cost of buying water by using pond water which is free and close to our house*' (KII, Traditional healer) (Table 7).

The proportion of households which shared water sources with animals increased from 15.0% in the rainy season to 61.4% in the dry season in Sanza, but decreased from 31.6% in the rainy season to 26.7% in the dry season in Iwondo. Sharing of water sources with animals differed significantly between wards in both seasons (P<.001) (Table 6). The KII and FGD participants connected increased water sources sharing with animals during the dry period with decreased number of available water sources in Sanza and reverting from using tap water to surface water during the rainy season in Iwondo.

A majority of participants in the KIIs and FGDs claimed not using water sources contaminated with animal faeces and urine because animals cannot drink directly from the wells and a few believed the contamination occurs because of the flow of urine and faeces from animals using the well for drinking water (Table 7). During the rainy season, the proportion of households which spent less than one-hour fetching water increased in both wards. On the other hand, time spent fetching water differed significantly between wards (<.001), being more in Iwondo in both seasons: in the dry season because most households source water from the public tap, which is relatively far from most households and in the rainy season. Knowledge of the methods and reasons for treating water was high among the participants in all wards. Despite the reasonable level of knowledge of water treatment revealed by FDG and KII participants, boiling of drinking water was practised by only 5.2% and 8.6% of the households in Sanza and Iwondo, respectively. A large number of participants claimed that boiling reduces palatability and others believed water used for drinking is safe, hence, that there was no need for boiling (Table 7).

Handwashing Before Meals and After Latrine Use

The proportion of questionnaire respondents reportedly using soap to wash hands before meals were 12.4% and 13.9% in Sanza and Iwondo (Table 8). These results are in agreement with the information given by KII and FGD participants in both wards, reporting to commonly washing hands without soap before meals. The proportion of households washing hands in a shared container was significantly higher in Sanza (40.5%) than in Iwondo (23.0%) (P=.001) (Table 9), however, FGD participants indicated this to be a common practice in the Barbecue selling points (i.e. street food vendors) were suggested as the areas where most people eat without washing hands. A little over half of the questionnaire respondents (51.8%) reported not washing their hands after latrine use. This was in agreement with most FGD participants. '*We occasionally wash our hands after using toilets, because we are not used to that practice*' (FGD, rich male) (Table 9). The percentage of households that reported not washing their hands after latrine use in Iwondo was almost twice (66.3%) that of Sanza (34.0%), with a significant difference between the two wards (P<.001) (Table 8). Water scarcity, failure to place water near the latrine or handwashing place and complete absence of a designated area for handwashing were the main reasons for not washing hands after toilet usage, as mentioned by a majority of the KII and FGD participants (Table 9).

Sanitation Services Availability and Use

The traditional pit latrine is commonly used in both of the study areas, by 99.5% and 96.6% of the enrolled households in Sanza and Iwondo, respectively (Table 10). High costs were mentioned by FGD participants as a major barrier to build improved latrines. Some participants did not see the justification for spending money building an improved latrine while they do not have an improved house, as summarised by a FGD participant: '*How can I use a lot of money to build the good latrine, while I am living in a poor traditional house?"* (FGD, Very poor female) (Table 11). Latrine sharing among households was more common in Iwondo (51.3%) than in Sanza (37.3%), and the difference between the wards was significant (P=.035). Temporary latrines commonly found in the areas are frequently destroyed by rain, leading the household members to use the neighbouring household's latrine.

Frequency of disposing children faeces in the latrine differs statistically significantly between wards (73.2% and 54.0% for Sanza and Iwondo, respectively) (P<.001) (Table 10), with FGD participants mentioning common alternatives for disposal being discarding faeces in the field or bushes, or covering with soil. The belief that children's faeces is harmless to human health and latrines being situated at a distance from the house was mentioned by FGD participants as reasons that discouraged disposal of children's faeces into latrines (Table 11). A small proportion of households practised open defaecation (2.6% and 2.7% in Sanza and Iwondo, respectively). This was reported to be most common amongst farmers and livestock keepers with relatively large areas for crop production and keeping animals; they stay in isolated seasonal camps and rarely build toilets.

Human-Chicken Interactions

Keeping chickens inside the house overnight was commonly practised by 81.7% and 75.4% of households in Sanza and Iwondo, respectively. (Table 12). The majority of the KII and FGD participants mentioned theft and predation as the reasons for keeping chickens inside the house (Table 13). The proportion of households reporting chickens gaining access to washed kitchen utensils was higher in Sanza than in Iwondo, and the difference was statistically significant between the wards (44.4% and 32.6%, respectively, (P=.034) (Table 12).

TABLE 3: . Themes and Selected Supporting Quotes Emerging From Key Informant Interviews (KII) and Focus Group Discussions (FGD), Describing Local Knowledge of the Occurrence and Causes of Diarrhoea and Children's Growth Stage Most Prone to Diarrhoea

Theme	Selected Quotes	Information Source	Participants
Knowledge of occurrence and causes of diarrhoea	'Diarrhoea is just like other diseases; it normally occurs without genuine cause.'	KII	Community leader 1, male
	'Diarrhoea episodes are frequently seen during the rainy season in all ages because during this period a lot of wild green vegetables are eaten, and the problem becomes more evident when the children start eating groundnuts from the farm.'	FGD	Very rich, male
	'To my understanding, the child must develop diarrhoea in every stage of growth; when they start sitting, crawling, standing and with the growth of the teeth.'	FGD	Very rich, female
	'When the child is given the food which has been kept overnight and other food.'	FGD	Rich, female
	'When the child is still breastfeeding and mother is practising sex.'	FGD	Very poor, male
	'When the mother breastfeeds the child while she is pregnant, this may result in the breastfed child developing diarrhoea because they will be suckling the baby's milk in the womb.'	FGD	Rich, male
	'Children under five are eating everything they encounter, some of which causes diarrhoea'	FGD	Very poor, male
	'Mostly observed during the rainy season because during this period most people use pond water, which results in people drinking contaminated water as when it rains all animal and human faeces are washed out towards the water sources.'	KII	Health volunteer worker 2, female
Child growth stage most prone to diarrhoea	'During complementary feeding stage, because of mixing the mother's milk with food in the child's gut.'	FGD	Very poor, female
	'Mostly observed when the child starts sitting or crawling because during this period the children eat dirt from the environments where humans and chickens are spending a day.	KII	Community assistant 1, female
	'During complementary feeding, because of inappropriate food preparation and handling, by feeding the children with cold food and allowing the flies and chickens to have access to children's food and the utensils.'	KII	Health volunteer worker 2, female
	'During weaning, itis associated with stress due to an abrupt stop from breastfeeding.'	FGD	Very rich, male
	'Mostly during crawling as the result of eating everything they encounter on the ground.'	FGD	Rich female
	'The child develops diarrhoea when they start to develop the molar teeth.'	FGD	Rich, male

TABLE 4: Types of Materials Used in the Construction of Houses of Study Participants in Each Ward, and the Overall Study Sample, Based on Questionnaire Responses

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Roof materials (%)				.002
Grass/thatch/leaves/mud	58.8	75.4	67.9	
Iron sheets	41.2	24.6	32.1	
Wall materials (%)				<.001
Grass	2.0	1.1	1.5	
Wooden poles and mud	35.3	70.5	54.4	
Sun-dried	28.8	17.6	22.7	
Baked bricks	32.7	9.6	20.0	
Wood, timber	0.0	0.5	0.3	

Continue

TABLE 4: Continued

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Cement bricks	1.3	1.1	1.2	
Floor materials (%)				.625
Unimproved floor	86.3	88.3	87.4	
Improved floor	13.7	11.7	12.6	
Presence of windows in house (%)				.371
Without windows	35.9	41.2	38.8	
With windows	64.1	58.8	61.2	

TABLE 5: Themes and Selected Supporting Quotes Emerging From Key Informant Interviews (KII) and Focus Group Discussions (FGD) describing local knowledge of the importance of cleaning the house, important features of an improved house and house cleaning practices

Theme	Selected Quotes	Information Source	Participants
Important features of an improved house and cleaning considerations	'We feel very uncomfortable to stay inside our traditional dwellings (tembe) which normally have no windows, because it is very hot inside during the night which sometimes makes us sleep outside.'	FGD	Very poor, male
	'A house with plastered walls and a cement floor looks beautiful and presentable.'	FGD	Rich, female
	'Unplastered walls can easily harbour even bedbugs, and once they are there they cannot be easily seen or killed, even with insecticide.'	FGD	Very poor, male
	'I don't see the difference between sand or soil and a cement floor. Both types serve the same purpose.'	FGD	Very rich, male
	'The house with a cement floor is easier to clean, you can use even water and soap to mop.'	FGD	Very poor, male

TABLE 6: Percentage of Seasonal Sources of Drinking Water and Treatment in Each Ward and the Overall Study Sample, Based on Questionnaire Responses

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Source of drinking water (%)				<.001
Dry season				
Stream/river/pond/dam	20.9	26.2	23.8	
Open wells	79.1	8.6	40.3	
Public tap	0.0	65.2	35.9	
Rainy season				
Stream/river/pond/dam	74.5	79.1	77.1	<.001
Open wells	24.8	0.0	11.2	
Public tap	0.7	20.9	11.8	
Source of drinking water (%)				
Dry period				<.001
Not shared with animals	38.6	73.3	57.6	
Shared with animals	61.4	26.7	42.4	

Continue

TABLE 6: Continued

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Rainy period				<.001
Not shared with animals	85.0	68.4	75.9	
Shared with animals	15.0	31.6	24.1	
Treatment of drinking water (%)		.067		
Boiling always	5.2	8.6	7.1	
Occasional boiling	3.9	9.1	6.8	
No treatment	90.9	82.4	86.2	
Time spent fetching water (%)				
Dry season				<.001
Within one hour	78.4	49.7	62.6	
More than one hour	17.7	43.3	31.8	
Unspecified	3.9	7.0	5.6	
Rainy season				<.001
Within one hour	93.5	79.6	85.9	
More than one hour	2.0	13.4	8.2	
Unspecified	4.6	7.0	5.9	

TABLE 7: Themes and Selected Supporting Quotes Emerging From Key Informant Interviews (KII) and Focus Group Discussions (FGD) Describing the Drinking Water Handling, Treatment and Water Source Sharing With Animals in the Study Area

Theme	Selected Quotes	Information	Participants
Water safety and the importance of water treatment	'In my house, the water is fetched in a big bucket and we start drinking right away.'	FGD	Very rich, male
	'When I fetch drinking water, I normally make sure the container is tightly closed all the time to ensure safety.'	FGD	Rich, female
	'We boil drinking water occasionally, not always.'	FGD	Very rich, male
	'Boiled water tastes different and does not quench the thirst.'	FGD	Rich, male
	'No need for boiling, because we are confident with the safety of our water.'	FGD	Very poor, female
Water source sharing with animals	'We do not share the same source of water with animals, rather we build traditional troughs (mrambo) beside the well then we take water from the well to fill up the trough for animals to drink.'	FGD	Very rich, male
	'Cattle, goats, sheep and donkeys are getting water from the river or temporary wells dug in the dry riverbed (korongoni), which is the same source of water for home use.'	FGD	Very rich, male
	'Animals are defaecating around the wells, therefore there is a high possibility of the faeces dropping into the wells.'	FGD	Rich, male
	'Wells cannot be protected from animal faeces and urine contamination, because during filling of the traditional trough (mrambo) there is water which splashes, resulting into backflow into the well.'	FGD	Very poor, female
	'At the small dams we have, you may find the cattle drinking and on the other side, the people are fetching water for home use. With this practice, there is a high risk of using water contaminated with animal faeces. I feel bad seeing people using such kind of water. They are using those water sources because they have no alternative.'	KII	Nurse 3, female
	'We are buying water from the public tap here, during the rainy season we cut the cost of buying water by using the pond water which is free and close to our houses, but it is used by animals as well.'	KII	Traditional healer, male

TABLE 8: Handwashing and Water Treatment Practices in Each Ward and the Overall Study Sample, Based on Questionnaire Responses

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Handwashing before meal (%)				.749
With soap	87.6	86.1	86.8	
Without soap	12.4	13.9	13.2	
Methods of handwashing (%)				.001
One by one in running water	59.5	77.0	69.1	
In a shared container of water	40.5	23.0	30.9	
Hand washing after toilet use (%)				<.001
With soap	66.0	33.7	48.2	
Without soap	34.0	66.3	51.8	

TABLE 9: Themes and Selected Supporting Quotes Emerging From Key Informant Interviews (KII) and Focus Group Discussions (FGD), Describing the Handwashing Practices During a Critical Time in the Study Area

Theme	Selected Quotes	Information Source	Participants
Hand washing practices before the meal	'Hand washing is mostly done before and after eating, but rarely before food preparation.'	KII	Community assistant, female
	'Some people do not wash hands thoroughly before eating; they just dip their hands in a bowl of water to make their fingers wet.'	FGD	Very poor, male
	'We do not use soap during washing hands because we are using clean water and we are sure that it is safe because it is the same water we are using for drinking.'	FGD	Rich, female
	'We do not use soap to wash our hands because we are not used to do so.'	FGD	Rich male
	'At the barbeque places, people who are preparing barbeques do not wash hands and do not put water for the customers to wash their hands.'	FGD	Very poor, male
	'Washing our hands before meals in the same pot, even if we are six people, is common here; a thing which is not proper because we are sharing germs on our hands, but not washing hands.'	FGD	Very poor, female
	'We do not always wash hands after toilet use and in most cases, if we do, we do it without soap.'	FGD	Rich, male
	'There is nothing we can do about leaving the toilet without washing hands because we were born and found things are done that way.'	FGD	Very poor, male
	'A large proportion of the households do not put water in the toilets for washing hands as it is a very expensive practice to maintain because we buy water here.'	FGD	Very rich, female

TABLE 10: Sanitation Facilities and Practices in Each Ward and the Overall Study Sample, Based on Questionnaire Responses

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Using latrine (%)				.759
Yes	97.4	97.3	97.4	
No	2.6	2.7	2.6	
Type of latrine used by household (%)				.094
Ventilated pit latrine	0.5	3.4	1.8	
Traditional pit latrine	99.5	96.6	98.2	
Latrine sharing among households (%)				.035
Not shared	58.1	46.2	51.5	
Shared with one or more households	37.3	51.3	48.5	
Disposal of children's faeces (%)				<.001
In a latrine	73.2	54.0	62.6	
Not in a latrine	26.8	46.0	37.4	

TABLE 11: Themes and Supporting Quotes Emerging From Focus Group Discussions (FGD), Describing the Availability and Use of Sanitation Facilities in the Study Area

Theme	Selected Quotes	Information Source	Participants
Availability of improved sanitation services	'It is very expensive to build the ventilated latrine'	FGD	Very rich, male
	'How can I use a lot of money to build the good latrine, while I am living in a poor traditional house?'	FGD	Very poor, female
Toilet sharing among households	'Several households organise themselves to build a toilet, and all households participating in the building of the toilet use that toilet.'	FGD	Very rich, male
	'Our latrines are not that strong. As a result, during the rainy season, latrines in some households get washed away by floods. This leads people to use the neighbouring latrine while waiting to build another one and not all households manage to rebuild their latrines.'	FGD	Rich, female
	'We are living in cooperation. Building a toilet for each household is a sign of segregating from each other.'	FGD	Rich, male
Open defaecation and children faeces disposal	'Open defaecation is mostly practised by the big farmers and livestock keepers because they live in isolation. When they clear the area for their activities, they do not build a toilet and end up defecating in nearby bushes.'	FGD	Very rich, male
	'We are farming away from where we are staying and on the farm, there is no latrine; therefore, when we are in the fields we help ourselves in the bushes or dig a shallow hole and cover it with soil when we are done.'	FGD	Very poor, female
	'I do not see that there is a need to dispose of the children's faeces in the toilet, which is not even close to my house, while it is just children's faeces, which have no problems like adult faeces; therefore, I normally dispose of it in the field.'	FGD	Rich, female

TABLE 12: Selected Variables Indicating Human-Chicken Interactions in Each Ward and the Overall Study Sample, Based on Questionnaire Responses

Variable	Sanza Ward (n=153)	Iwondo Ward (n=187)	Overall Study Sample (N=340)	P Value
Chicken roosting locations (%)				.187
Inside the house	81.7	75.4	78.2	
Not inside the house	18.3	24.6	21.8	
Access of chickens to pots and plates (%)				
Before washing				.264
No access	22.9	28.9	26.1	
Access	77.1	71.1	73.8	
After washing				.033
No access	55.6	67.4	62.1	
Access	44.4	32.6	37.9	
Drinking water containers				.012
No access	52.3	38.5	44.7	
Access	47.7	61.5	55.2	
Access of chicken to human faeces (%)				<.001
No access	37.9	23.5	30.0	
Access	62.1	76.5	70.0	

TABLE 13: Themes and Supporting Quotes Emerging From Key Informant Interviews (KII) and Focus Group Discussions (FGD), Describing the Public Health Risks Associated With Chicken Keeping Practices in the Study Area

Theme	Selected Quotes	Information Source	Participants
Reasons for keeping chickens inside the house overnight	'We have a chicken house but when you keep chickens outside in their houses, they are attacked by the cats.'	FGD	Very rich, male
	'We prefer to keep our chickens inside because when left outside in their house they get stolen.'	FGD	Very rich, male
	'We were born and found our parents keeping the chickens inside the house and we are continuing doing the same.'	FGD	Very poor, female
	'The number of chickens also matters. There is no way I can waste my energy to build a house for only five chickens.'	FGD	Very poor, female
Effects associated with keeping chicken inside the house overnight	'There is no problem, maybe mite infestations to humans, but I don't think it is a big problem.'	KII	Community leader
	'Chickens are carrying insects including ticks and mites which attack humans, and when you become infested by these insects you cannot sleep at night.'	FGD	Rich, female
	'Chicken is eating human faeces, especially from children who have not yet started to use the latrine, and dirt that remains on the beaks and legs can lead to contamination of the pots and transmit diseases.'	KII	Nurse 3, female
	'Keeping the chickens in the house overnight makes the house smell bad, because of chicken faeces.'	FGD	Rich, male

TABLE 14: Mixed Method Analysis of the Qualitative and Quantitative Data Related to the Key Areas Explored

Key Areas	Qualitative Findings KII (n=10) and FGD (n=61)	Quantitative Findings Questionnaire Surveys (N = 340)	Mixed Method Interpretation
Community knowledge on the causes of diarrhoea in children	• 'To my understanding, the child must develop diarrhoea in every stage of growth; when they start sitting, crawling, standing and with the growth of the teeth.' • 'Children under five are eating everything they encounter, some of which causes diarrhoea.'	Causes of diarrhoea (multiple responses possible): • Growth stages (44.4%) • Unhygienic environment (28.2%) • Drinking unsafe water (25%) • Unhygienic food handling (23.8%) • Eating without washing hands (20.3%) • Partially cooked food (11.8%) • Chickens access to the utensils (7.1%)	Both data sets indicate mosr participants relate particular growth stages with the occurrence of diarrhoea in children. Other important causes, including open defaecation and a dirty house environment, were not mentioned (qualitative data) or rarely selected (quantitative data). Both data sets indicate a knowledge gap on the causes of diarrhoea.
Child growth stage in relation to high incidence of diarrhoea	• 'During complementary feeding stage, because of mixing the mother's milk with food in child's gut.' • 'Mostly observed when the child starts sitting or crawling because during this period the children eat dirties from the environments where humans and chickens are spending a day.'	Growth stage was reported to be most affected by diarrhoea, amongst children under five years of age: • Exclusive breastfeeding period (15.9%) • Complementary feeding (41.9%) • Weaning period (10.3%) • All stages are the same (24.2%)	Both data sets are in agreement that diarrhoea mostly occurs during the complementary feeding stage, despite some incorrect reasons reasons for the increase in the frequency of occurrence of diarrhoea during this period provided by FGD and KII participants.
Relationship between seasons and occurrence of diarrhoea	'Mostly observed during the rainy season because during this period most people use pond water, which results in people drinking contaminated water as when it rains all animal and human faeces are washed out towards the water sources.' 'Diarrhoea episodes are frequently seen during the rainy season in all ages because during this period a lot of wild green vegetables are eaten, and the problem becomes more evident when the children start eating groundnuts from the farm.'	Use of stream, river, pond or dam as the source of drinking water: • Dry season (77.1%) • The rainy season (81.3) Households spending less than 1 hour to fetch water: • Dry season (62.6%) • The rainy season (85.9%)	Both data sets show shifting to streams, rivers, ponds or dams as the main source of water in the rainy season. Changes in the time spent fetching water between seasons indicate an increase in surface water use in the rainy season. Relating diarrhoea with the type of food further indicated a knowledge discrepancy in the causes of diarrhoea.
Use of water contaminated with animal faeces and urine	'We do not share the same source of water with animals, rather we build traditional troughs (mrambo) beside the well then we take water from the well to fill up the trough for animals to drink.' 'At the small dams we have here, you may find the cattle drinking, and on the other side, the people are fetching water for home use.'	Households using drinking water sources shared by animals: • Dry period (42.4%) • Rainy period (24.1%)	Both data sets are in agreement that there is a significant proportion of households using surface water contaminated with animal faeces. The mismatch seen in qualitative data on the the level of understanding of how the water can be contaminated with animal faeces, as seen in these two quotes in qualitative data, may results in under-reporting of the households using water contaminated with animal faeces in quantitative data,

Continue

TABLE 14: Contnued

Key Areas	Qualitative Findings KII (n=10) and FGD (n=61)	Quantitative Findings Questionnaire Surveys (N = 340)	Mixed Method Interpretation
			may results in under-reporting of the households using water contaminated with animal faeces in quantitative data, hence the latter should be interpreted with caution.
Handwashing practices	'We do not use soap because we are using clean water and we are sure that it is safe as it is the same water we are drinking.' 'Washing our hands before meals in the same pot, even if we are six people, is common here; a thing which is not proper because we are sharing germs on our hands, but not washing hands.'	Households washing hands with soap: • Before meals (13.2%) • After using the toilet (48.2%) • Methods of hand-washing: • One by one in running water (69.1%) • In a shared container (30.9%)	Both data sets indicate rare use of soap during handwashing before meals and after latrine use as well as ineffective handwashing. Qualitative data indicate that some people are aware of the health effects of these practices, despite continuing to do otherwise.
Effect of chicken gaining access to kitchen utensils	'Chickens are eating human faeces, especially from children, who have not yet started to use latrines, and enter every part of the house which predisposes the pots and food to human faecal contamination.'	Access of chickens to: • Unwashed cooking and serving utensils (73.8%) • Washed cooking and serving utensils (37.9%) • Water containers (61.5%) • Human faeces (70.0%)	Both data sets complement each other by showing the existence of the access of the chickens to kitchen utensils and access of the chickens to human faeces which both indicates the possibility of using the utensils contaminated by human faeces.

The difference in the number of chickens drinking water from household water containers was significant between wards, being more commonly reported in Iwondo (61.5%) than in Sanza (47.7%) (P=.012). Unimproved houses for household members, keeping chickens under scavenging production systems, and keeping chickens in the house overnight were mentioned by KII and FGD participants as the main reasons for chickens drinking water from household containers. Chickens gaining access to human faeces was reported in 62.1% and 76.5% of the households in Sanza and Iwondo, respectively, and differed significantly between wards (P<.001). Human infestation with external parasites (e.g. mites, fleas, lice and ticks), smell of chicken faeces in houses, and contamination of the house and kitchen pots with human faeces carried in by scavenging chickens were the health problems mentioned as more likely to occur under such human-chicken interactions (Table 13).

Data Triangulation

The quantitative and qualitative datasets were merged and compared to identify the areas of convergence, divergence and mutual complementarity. This enabled a deeper understanding of the messages communicated by the available data. Both sets of data showed a clear gap in knowledge of the causes of diarrhoea, which was considered as normal event occurring during the growth stages of children under five years of age. Questionnaire survey data showed a marked shift from using public tap water during the dry period to relying on streams, rivers, ponds or dams during the rainy season, especially in Iwondo. This shift was well explained by FGD participants, who indicated more households using water from open sources during the rainy season because it was free of charge, available and convenient.

Information on sharing of water sources with animals was gathered in the questionnaire survey to capture the proportion of households using water potentially contaminated by animal faeces and urine. Some FGD participants considered water from the well to be shared only if animals were able to drink directly from the well, not from troughs built beside the well. Therefore, the number of households using water potentially contaminated with urine and faeces from animals may be underrepresented in the questionnaire survey, as contamination can occur even if animals are drinking from areas adjacent to the well. More detailed information on data triangulation is presented in Table 14.

DISCUSSION

This study provides an insight into the housing, water supply, hygiene and sanitation challenges that households face in resource-poor settings in rural communities of central Tanzania. Despite differences in gender, and socio-economic status, there was very little variation in the responses given by the participants from different FGD groups. For example, in Iwondo Ward, all groups claimed to use water from streams, rivers, ponds or dams during the rainy period for financial reasons, regardless of their economic status. Although there were significant differences in many of the variables tested between wards, the prevalence of diarrhoea in children was not significantly different, which may be an indication of these areas not sharing common determinants of diarrhoea and/or the potential for other important variables, not included in this study, to drive prevalence. Nonetheless, both categories of the data indicate the common drinking water sources, hygiene practices, existing type and use of sanitation facilities and animal-human interactions which may be contributing factors to the observed prevalence of diarrhoea in each ward.

Among important variables that differed significantly between wards, Sanza had a higher percentage of households washing hands in a shared container of water before meals, sharing sources of water with animals during the dry season and allowing chickens to access washed utensils. On the other hand, Iwondo had a higher percentage of multiple households sharing latrines, not disposing of children's faeces in the toilet, spending more time fetching water in both seasons, not washing hands with soap after toilet use, and allowing chickens to gain access to human faeces. All of these practices could increase the risk of developing diarrhoea, which may explain the similar reported prevalence of diarrhoea cases. Additionally, there was a shared seasonal pattern of sourcing drinking water, whereby in both wards the percentage of the households accessing water from a stream, river, pond or dam increased by more than three times in the rainy season, compared to that observed during the dry season. There was a significant difference in the perception of the age groups more prone to diarrhoea between wards, but this could have been due to failure to recognise age-specific predisposition to diarrhoea in some households in both wards. In general, commentary reporting increased diarrhoea episodes under five years of age was observed frequently among KII and FGD participants. This supports the general observation produced in the questionnaire data that children under five are seen to be more prone to developing diarrhoea in this area.

Although the differences in house roofing and wall materials were statistically significant, these did not appear to greatly influence the frequency of diarrhoea in these two wards. The majority of houses in the study areas were made up of a soil roof and walls made from mud and wooden poles. This type of house has small windows and is sometimes windowless, which may affect the effectiveness of house cleaning if there is no enough light admitted to make dirt easily visible to the cleaner. Additionally, sunlight has been reported to have bactericidal effects which may help to reduce the microbial community built up and survival on the house floor and walls.[19,20] Unimproved floors (without cement) and walls (without plaster) were mentioned by many participants as one of the obstacles to effective house cleaning, as mopping with water and soap is not possible on such surfaces. Unimproved floors are difficult to clean and are more likely to contain high microbial populations than cement floors, as reported in one study conducted in Peru.[21] Chicken, rat, bat and owl faeces and chicken feathers were commonly encountered in the houses and many of these animals have been implicated in harbouring pathogens of zoonotic importance.[22,23,24]

Availability of free surface water during the rainy season was the reason for a large proportion of the households shifting from using tap water to surface water, especially in Iwondo, where tap water is frequently used by a

relatively large proportion of the households in the dry season. The Tanzania National Water Policy of 2002 directs the establishment of user-pays water schemes, operated and maintained by communities.[25] One borehole and two windmills in the Sanza Ward were not working during the data collection period, because community members could not afford to pay for the service, which is the source of funds for repair and buying fuel (personal communications from the Sanza Village Executive Officer). Unless current financial conditions improved in rural areas, the effective use of upgraded sources of water for improving community health will remain hard to achieve. Communities will continue to turn to unimproved water sources for financial reasons.[7] The proportion may differ between seasons, but both wards use water potentially contaminated by animal faeces through the sharing of water sources with animals and using rain water run-off. This predisposes community members to pathogens associated with animal faeces.[26] Home water chlorination and boiling can be promoted to mitigate these effects, as it has been reported to be effective in the control of diarrhoeal diseases in children in Ethiopia and Nepal, respectively.[27,28] However, some people in the study areas and elsewhere consider boiled water unpalatable for drinking.[8]

Effective handwashing can be achieved by cleaning under the fingernails and rubbing the fingertips with soap under running water.[29] The use of soap during handwashing was rare in the study areas and washing hands in shared containers of water were practised by a reasonable proportion of households, which may be contributing to the prevalence of diarrhoea observed. Most households do not ensure availability of water for handwashing in the latrine and do not have designated areas for handwashing. This forces household members to carry water with them when visiting the toilet or to collect water from the house for handwashing after toilet usage. The latter practice may predispose utensils and water within the house to human-faecal contamination. Encouraging behavioural change based on emotional drivers through hygiene promotion campaigns may be appropriate in these areas, as it has been more effective in advancing behaviours of handwashing with soap than a cognitive approach.[30,31] Training of stakeholders on hygienic food handling at ready-to-eat food selling points, especially the barbecue areas, and instituting by-laws related to food hygiene may build good 'hygiene habits' among the community during their outdoor activities.

Keeping chickens inside the house overnight, as is commonly done in the study areas as a precaution against theft and predation, results in external parasite bites on humans. This not only causes a significant nuisance, but can be associated with allergic conditions, for example, flea bite dermatitis, and can transmit zoonotic diseases.[32] Host-associated genetic markers in rural Bangladesh indicated an occurrence of avian faecal markers more frequently in the soil, hand rinses and stored water from households owning birds.[11] However, the participants in the current study were more concerned about the role of chickens in contaminating utensils with human faeces, than direct contamination with chicken faeces. The current study indicates access to human faeces being common amongst scavenging chickens, due to poor disposal of faeces and poorly constructed latrines which are easily accessed by chickens. Placing utensils in large containers with lids may solve the problem, as this deters not only chickens but also rats, bats and other animals and insects from gaining access to utensils. The knowledge of the community on the health effects associated with living with chickens under the same roof was centred mainly on the direct effects of ectoparasite transmission, while the effects of potential diseases transmission due to avian faecal contaminations were not known. Animals are potential sources and transmitters of gastrointestinal infections and their role should be well addressed in water, sanitation and hygiene intervention programs implemented in extensive livestock-keeping communities.[33]

More than 90% of the households in both wards use unimproved latrines and nearly half of all households share latrines. As reported in other studies,[34,8] high construction costs were pointed out by most KII and FGD participants in the study areas as the factor that prevented access to improved latrines. Children's faeces were perceived by many participants of FGD and KII as being free from pathogens causing human diseases. Hence, proper disposal was not considered necessary, predisposing the house compounds to human-faecal contaminations. Latrine sharing, improper disposal of children's faeces, open defaecation and dirty latrines have been reported in different countries as risk factors for developing mild and severe diarrhoea in children.[35] Among others, children growth stages was mostly mentioned by the questionnaire respondents as the main cause of diarrhoea in children in the current study. This belief needs to be addressed through greater awareness of the risk factors associated with diarrhoea among community members.[36] Despite their importance, the practices of inadequate cleaning of utensils, not using latrines, washing hands in a communal basin, and access of chickens to the kitchen utensils were rarely mentioned as the possible causes of diarrhoea. In Sanza, the occurrence of diarrhoea was reported to be related to eating fresh foods that are plentiful during the rainy season; however, this is more likely due to the use of surface water, which is abundant during this period but should not be perceived to have a causal relationship. The current study like another study[37] indicates increase in diarrhoea cases in children during the complementary feeding stage. Complementary feeding involves the provision of other food and liquids along with breastfeeding, normally between 6 to 24 months of age, when breast milk alone is no longer adequate to meet the nutritional requirements of infants, however, for some reasons, complementary feeding is sometimes introduced before 6 months of age. Apart from consuming contaminated food, this is a stage when children are sitting and crawling. This results in mouthing potential contaminants, including animal faeces from the soil, as well as soil itself, predisposing them to gastrointestinal infections.[38,39] Children from households practising free-range as the means of raising animals are more likely to acquire animal-derived gastrointestinal infections, due to the contamination of compounds with animal faeces.[40] However, evidence exists showing that childhood contact with livestock can be associated with improved human immune system function, particularly around allergic responses.[41] In addition, livestock ownership was

associated with animal source food consumption and increased expenditure on human healthcare, leading the authors to conclude that interventions that improve general animal health may have the greatest impact on human health through increasing household wealth.[41]

The Tanzanian Government's Vision 2025 promises to increase access to improved sanitation services to 95% of the population, fighting against water, sanitation and hygiene-associated diseases that are estimated to absorb 70% of the total health budget.[42] Furthermore, the Tanzanian Government, along with 192 other nations, has committed to achieving Sustainable Development Goals 6, focuses on achieving equal access to safe, sufficient and affordable drinking water and sufficient sanitation and hygiene services by 2030.[43] Deaths of under five years of age attributed to diarrhoea in Tanzania decreased from 14% in 2000 to 8% in 2016 i.e. a decrease of 24,466 to 9,441 of total deaths in children under five years of age.[44]

Improved water supply, sanitation and hygiene services form an integral component in the control of diarrhoea in children and have contributed largely to the achievements recorded during this period. Despite these achievements, access to important services which are vital for diarrhoea control, have not been equitably distributed between rural and urban areas. This is contrary to the 2030 Agenda for sustainable development, which advocates reducing inequality and leaving 'no-one' behind.[45] This is evident in Tanzania, whereby in 2016 the proportion of rural households in the Tanzania mainland depending on unimproved sources of drinking water was almost four times higher than that in urban areas.[2] Provision of improved water sources under a user-pay community program, designed to ensure sustainability (as directed in National Water Policy of 2002), may not work in many rural areas as significant numbers of households tend to turn to unimproved water sources during the rainy period. This tendency is due to convenience and financial constraints as documented by this study, which is in agreement with another study conducted in other rural areas of Tanzania.[7] Until living standards are improved in rural areas, households will have difficulty affording user-pay fees system. Alternatives, including government subsidies, should be taken into consideration to reduce the service access gap between rural and urban areas.

CONCLUSION

The barriers to the use of safe water in resource-poor settings are not limited only to availability, but also to affordability, convenience and prioritisation of financial resources. Based on findings of the current study, the immediate manageable areas of control of childhood diarrhoea should be directed at water treatment at household level and preventing recontamination, reduction of children-chicken interaction and chicken access to kitchen pots to prevent chicken-faecal contamination, proper human faeces disposal to reduce possibility of chickens transferring human faeces to kitchen pots and children, and educating community on the causes of childhood diarrhoea. Educating the communities on the multifaceted nature of risk factors associated with childhood diarrhoea is an important step towards better use of available resources to control childhood diarrhoeal diseases.

It is recommended that the Government of Tanzania develop area-specific water policies as the user-pays for service system used countrywide has not been successful in many rural areas.

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Peer Reviewed

Acknowledgments: The authors gratefully acknowledge the local leaders, Community Assistants, enumerators and villagers from Sanza and Iwondo Wards for their contributions; Manyoni and Mpwapwa District Councils for granting us permission to conduct this study.

Competing Interests: None declared.

Funding: Financial support from the Australian Centre for International Agricultural Research (ACIAR) in the form of a John Allwright Fellowship for the lead author and support for fieldwork through project No. FSC/2012/023, [http://aciar.gov.au/]: "Strengthening food and nutrition security through family poultry and crop integration in Tanzania and Zambia"; and from the University of Sydney Marie Bashir Institute Strategic Research Fund are gratefully acknowledged..

Received: 03 June 2022; **Accepted:** 05 October 2022

Cite this article as Rukambile E, Muscatello G, Kalloka M, Bagnol B, Stellmach D, Alders R. Hygiene Practices, Water Supply, Sanitation, and Childhood Diarrhoea in Resource-Poor Settings of Rural Central Tanzania: A Mixed-Method Study. East Afr Science J. 2023: 5(1): 48-66. https://doi.org/10.24248/easci.v5i1.75