Relation of Sanitary Conditions of Water Sources and Water Borne Diseases in Rural House Holds of South India

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Abstract

Background: Access to safe drinking water has long been a central aim of public health. In India 85% of rural house holds have access to drinking water within or near to their premises through any improved sources and 70% of the household water sources were polluted with sewage. Water borne disease (WBD) account for 10% of total burden of disease.

Objectives: To assess the sanitary conditions of household drinking water sources, and hygienic practices of community and the incidence of water borne disease. To find out the relation of water borne disease with the former two parameters.

Methodology: A longitudinal study was conducted in the Kerala state of India including 1459 persons from 300 households as study subjects. Water samples were collected and analysis was done. The data analysis was performed using SPPSS 16 version.

Results: During the 12 month follow up period 72 episodes of water borne disease were reported with an incidence rate of 49/1000 person years. Dug wells were the major household water sources (93.3%)and up to 30% water sources contain indicator bacteria Escherichia coli ,and more than 60% water sources contain Fecal coli from >10MPN/100 ml in all the seasons. Stagnant water at their premises was found to be associated with WBD (RR=3.58, 95% CI 1.90 -6.73, P=0.01) and proximity within 15meters from the septic tanks was found to be associated with increased incidence of WBD (RR=2.2, 95%CI 1.00- 4.63, P=0.04).

Conclusion: Our study found that improved water sources are not free from bacteriological contamination. The structures which included in the criteria for a sanitary well may not always protect the consumers from the risks of WBD.

Key words: Drinking water source, Water quality, dug well, Hygiene, Water borne disease

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Introduction

Access to safe drinking water has long been a central aim of public health and international development policy and water has a profound effect on human health both as a means to reduce disease and as a medium through which disease-causing agents may be transmitted.[1] The provision of water was one of the eight essential components of primary health care at Alma-Ata declaration in 1978.[1] The global community committed itself, by adopting the Millennium Development Goals (MDG), to halving the proportion of people without sustainable access to safe drinking-water and basic sanitation, by 2015.[1,2] The proposed Sustainable Development goals (SDG) declared in 2015 is to achieve universal and equitable access to safe and affordable drinking-water for all by 2030.[3] Providing disinfected piped water, to each household is the best solution to waterborne disease (WBD), due to resource constraints which is not available in most of the developing world.[4] On this reality the WHO Joint Monitoring Committee (JMC) adopted 'Use of an improved source'' as an indicator for monitoring access to safe drinking water, presuming that it will not risk health.[5,6,7]

In India as per the latest statistics 85% of rural house holds have access to drinking water within or near to their premises through any improved sources and 70% of India's improved house hold water sources were polluted with sewage effluents.[8,9] India ranks 120th among the 122 nations in terms of quality of water available to its citizens.[9] Water borne disease (WBD) account for 10% of total burden of disease and it affect about 50 million people every year in India and it claim about 5 million lives of which 1.5 million are children.[9,10]

Conventionally the key factors believed to be for the prevention of WBD are sanitation, personal hygiene and availability of good quality drinking water. But recently quantity of water also got equal or greater importance with attributable risk reduction of 39%.[5, 11]

The relation between sanitation and WBD was higher than water quality and WBD were reported in most scientific publications during the late 20th century.[4,7] Many studies from other developing

countries found that the relation between water quality at the source and WBD were lower than sanitation and treatment at point of source.[4,6,7,12] Though majority of rural population depends upon house hold improved water sources very few studies were done in these aspects in India.

The water quality and quantity varies with climate as water borne disease which may influence the results. But most of the studies were done cross sectional reported only point prevalence, with recall bias which tend to under estimate and not adequate to explain the relation.[9,13,14,15] In this context to assess the incidence of water born disease with relation of sanitary conditions of household drinking water sources, and hygienic practices of community a longitudinal prospective study was conducted in the Kerala state of India.

Methodology

The longitudinal study was conducted in South Indian state Kerala from July 2013 to August 2014.The state has 65.95 lakhs house holds and 50 Lakhs wells enumerated with density ranging from 120-150 wells per square kilometre.[16,17]

Study area: Kozhikode district was purposively selected .which is located in the western coast of Kerala situated between north latitudes 11° 08' and11° 50' and east longitudes 75° 30' and 76° 08'. The district has an area of 23445 square kilometer; topographically it is divided into sandy coastal area, laterite mid land area and rocky high land area. According to the 2011 census Kozhikode district has a population of 3,089,543, has a population density of 1,318 per square kilometer. According to the topography (Coastal, midland, hilly) three rural areas (Grama panchyats) were selected Chemenchery, Mavoor, Puduppady.

Sample size: In a previous reported study the prevalence of WBD was 23%, at 95% CI and an error of 20% the minimum sample size calculated was 300.[17]

Selections of house holds were done by multistage method**.** From the selected areas, 3 revenue wards were selected randomly and from each ward 100 houses were selected to get the required sample size of 300. All the enumerated residing household members (n=1459) were included as study population.

The study protocol was approved by the institutional ethical committee (IEC) Medical College, Calicut Data collection, drawing water samples was done after getting voluntary written informed consent from the head of the house holds.

Data collection

The household data collection was done by selected, trained women health workers (1 per 50 houses, 6 persons) by conducting weekly house visits prospectively for 12 months using the tool pre tested structured proforma. Demographic, housing, Socio economic, environmental, sources of drinking water, hygienic practices, water borne diseases (WBD) morbidity details were collected. Sanitary inspection of water sources was done using a standard check list.

Definition

Water-borne diseases are diseases caused by the ingestion of water Contaminated by human or animal faeces or urine containing pathogens.[11]

Diarrhea (ADD) was defined as three or more loose stools during a 24-hour period. A diarrhea episode was marked as a new episode if the person had two or more days without diarrhea. All the reported morbidities the diagnosis was cross checked with available medical records.

By sub sampling using systematic random method 10 houses were selected in each ward (10X3 =30) and from 30 drinking water sources water samples were collected and analysis was done thrice corresponding to the seasons (July, December, May) from Centre for Water Research Development Management (CWRDM lab) Calicut using standard Technique

Analysis

The data analysis was performed using SPPSS 16 version. According to the type of data the association/correlation was tested either by chi-square/Pearson and spearman coefficients. The relation of WBD with different qualitative/ quantitative variables was analyzed. The morbidity was measured as incidence rates. The relation was expressed as relative risks (RR) at 95% confidence limits (95 %CI).

Results

From 300 households, total 1459 persons were enrolled as study subjects (100%) with an average family size of 4.9 members. There were no non responders. The mean age was 30.4$\pm$20 years. The sex wise and religion wise distribution were given in Table 1.

All the houses had water seal toilets. Dug well was the main drinking water sources in 280 (93.3%) house holds. In 85.6% of the houses water was available around the year.

During the 12 month period 605 episodes of morbidities were reported among the cohorts of which 72 were water borne disease, incidence of 49/1000 person years. The proportional morbidity due to WBD was 11.9%. The WBD reported were ADD, dysentery and hepatitis A. The details were given in Table 2. Twenty three episodes of WBD (34%) were among children of age group 0-5 years (n=130,) consisted 8.9% of population.

The characteristics of water sources and hygiene practices and the relation with WBD are given in Table 3.

Since major source (93.3%) was dug well analysis of the relation with the sanitary conditions (parapet, platform, plaster, covering etc) with the incidence of WBD and its relative risks were given in Table 4.

Up to 30% water sources contain indicator bacteria Escherichia coli (E.coli) in summer and winter samples and more than 60% during rainy samples. Correspondingly more than 60% water sources contain Fecal coli from (F coliform) >10MPN/100 ml in all the seasons and the count was markedly increased during monsoon samples.

The mean distance from house to water sources was 7.7±12.2 meters and the mean distance between well and septic tank was 13.8±3.2 meters. The incidence of WBD has got negative correlation with distance from septic tank (r= -0.118, P=0.53). The distance from septic tank has got significant correlation with E.coli (r= -0.37, P=0.02) and Fecal coli (r=-0.43, P=0.04) during summer season.

Table 1: Demogrphic details of the study population(n=1459)

Characteristics	Number/mean	Percentage/ SD
Average Family size	4.9	±2.3
Sex		
Females	746	51.1%
Males	713	48.9%
Age in Years (Mean)	30.4	±20
Age group: Children <5 Years	130	8.9%
Religion		
Hindu	99	33%
Muslim	174	58%
Christians	27	9%
Educational status (n-1329)	912	68.6%
≤10th standard	211	15.9%
Plus Two	174	13.1%
Graduation		
Average Land holding –Cents	28.2	±55

Table 2: Details of Reported Water borne diseases(n=72)

WBD	Frequency	Proportion %	Incidence Per 1000 /year
ADD	48	66.7	34
Dysentery	13	18.0	8.9
Hepatitis A	11	15.3	7.5
Total WBD	72	100	49

Table 3: Relation of sanitary practice /environment with Incidence of WBD(n=300)

No	Hygiene practices	Frequency	WBD Incidence rate %	Relative Risk (95% CI)	P value
1	Muslim Religion	174	22.5	3.57 (1.50-8.77)	0.01*
	Other Religion†	126	6.3	1	
2	Near by any water bodies<100 meter	95	21.1	2.05 (1.15-3.64)	0.01*
	Away from any water bodies.>100 meter†	205	10.3	1	
3.	Solid waste-Composting	27	16.7	1.26 (0.49-3.24)	0.64
	Solid waste -Not composting †	273	15.3	1	
4	Liquid waste discharging to Soak pit	166	16.5	1.78 (0.94-3.30)	0.07
	Liquid waste not discharging to Soak pit†	134	8.5	1	
5	Over head tank PVC	223	14.3	1.87 (0.60-5.80)	

	Over head tank-Concrete †	39	7.6	1	0.25
6	Storing water in Kitchen –Metallic	196	13.7	0.95 (0.51-1.79)	0.87
	Storing water in Kitchen- earthern pots ,others †	83	14.5	1	
7	Using fridge	88	14.9	1.18 (0.64-2.18)	0.60
	Not using fridge †	212	12.7	1	
8	Treatment of water –Boiling	286	13.2	0.88 (0.30-2.61)	0.82
	Treatment of water- Not Boiling †	14	17.6	1	

†=Reference * P=<0.05 Significant.

Table 4: Factors of the dug well and Incidence of WBD (N=280)

No	Sanitary Condition of the source	Frequency	WBD Incidence rate %	Relative Risk (95% CI)	P value
1.	Own well	241	11.9	0.61 (0.33-1.16)	0.14
	Not Own well †	39	14.3	1	
2	Stagnant water -Present	26	37.5	3.58 (1.90-6.73)	0.01*
	Stagnant water -Absent †	254	10.5	1	
3	Parapet -Present	261	13.4	2.94 (0.39-60.73)	0.28
	Parapet -Absent †	19	0.5	1	
4	Platform -Present	200	12.8	1.10 (0.54-2.24)	0.79
	Platform -Absent †	80	11.7	1	
5	Inner Plaster -Present	169	14.5	1.33 (0.69-2.55)	0.39
	Inner Plaster -Absent†	111	10.9	1	
6	Well covered	248	12.4	0.77 (0.34-1.72)	0.52
	Well not covered †	32	25	1	
9	Motorized	261	13.5	2.56 (0.37- 17.66)	0.30
	Not motorized †	19	5.3	1	
7 **	Soak pit distance <15 meter	149	18.1	4.89 (0.69-34.5)	0.08
	Soak pit distance >15 meter†	27	3.7	1	
8	Septic tank distance <15 meter	190	16.8	2.2 (1.0- 4.63)	0.04*
	Septic tank distance >15 meter†	90	7.7	1	

†Reference * P=<0.05 Significant. **n=176.

Discussion

We conducted a one year longitudinal study in a selected rural area of south India among 300 houses holds with 1459 individuals. The environmental and hygiene practices were recorded by sanitary survey and details of morbidity was collected by conducting weekly house visits and the water samples from the point sources were analyzed thrice according to the seasonality.

The 93.3% had dug well as the water source and majority (86%) within the premises. At the state level 62% house hold sources of water were dug well.[16] The entire households had sanitary toilets of water seal type and zero open defecation. Due to constraints in land availability the mean distance between septic tank and water source was less (13.8±3.2 meters). 68% of wells were within 15 meters from septic tank which was below the prescribed minimum distance 15 meters by WHO.

During the 12 month period of follow up the incidence of WBD was 49/1000 which was less than previously reported from the state as 84 and 78/1000 per year which showed a declining time trend.[17,18] The proportional morbidity due to WBD was 11.9% which was similar to the previous report from the country.[10] The main reported WBDs were ADD (2/3rd), Dysentery and hepatitis (Table 2). As a development paradox being in the late phase of epidemiological transition the state now experience out breaks of hepatitis.[18] As reported else were, compared to other age groups the

children of 0 to 5 years have high morbidity due to WBD which was 177/1000 with a relative risk of 3.61 (95% CI 2.6- 4.7).

In our study it was found that Muslim religion have higher risk of WBD compared to others (RR=3.5, P=0.01) may be due to unknown confounders. Proximity of the house hold with any water bodies (<100 meters) like river, streams and canals have got higher risk of WBD (RR=2.0, P=0.01), which may be due to contamination during flooding or leaching through the soil layers. (Table 3). Though statistically non significant, the hygiene practices like composting of solid wastes and discharging liquid waste to soakage pits also have increased risk of WBD (RR=1.3, P=0.64 and RR=1.8, P=0.06) may be due to the proximity to dug well.

The availability of water at the premise was found to be protective which indirectly give the clue about the importance of water quantity than quality. As a proof those who are having own well have reduced incidence of WBD (11.9% vs14.3%) compared to others (RR=0.61, P=0.14).

Since for 93.3% of the households dug well were the water source their attributes were analyzed and discussed in details (Table 4). As per the 'protected well' criteria 71.4% had platform around their well, 93.2% had parapet, 60.4% had inner cement plastering, 88.6% had any covering and 93.4% had electric motor to lift water. In our study the above listed sanitary criteria were found to be not associated with any protection from WBDs (RR <1 and P=>0.05) except 'covered well' which was also not significant (R=0.77, P=0.52) Table 4. Though these sanitary inspection parameters were included in national and international water quality assessment guide lines, for comparison on literature search no such studies were available[1,5,8]. In the few available studies from India the water sources were not dug wells.[9,13] In a previous study the parapet was found to be protective (P=0.04).[16] Even though the majority of wells were motorized to lift water, for drinking and cooking purposes people prefer to use coir and bucket to draw water which may act as a path of contamination. It was reported that 9.3% of the dug wells had stagnant water at their premises which was found to be associated with WBD (RR=3.58, 95% CI 1.90 -6.73, P=0.01).

To prevent contamination the water source must be situated at least 15 meters away from septic tank or soakage pits.[19] Two thirds (65.3%) of the water sources were situated within 15meters from the septic tanks and was found to be associated with increased incidence of WBD (RR=2.2, 95%CI 1.00- 4.63, P=0.04). Similarly the proximity to soakage pit within 15 meters were also associated with WBD (RR=4.89, P=0.08). Our study also explained the sources of contamination as septic tank by the negative correlation of E.coli (r= -0.37, P=0.02) and Fecal coli form count (r=-0.43, P=0.04) with it's proximity to water sources. Similarly another study from the district reported presence of Fecal coli forms in 68% of samples with significant correlation (r=- 0.47, P=0.01) with distance between the septic tank and well.[19]

Recent systematic reviews found that the existing water quality indicators were not predictors of WBD in tropical countries.[6,12] As there are multiple pathways of contamination, many studies from the tropical countries reported that more than the water quality at the source the method of storage, treatment at the point of use at the house holds is the predictors of WBD.[12,20] Many authors suggested that the storage, treatment at point use are important than water quality at source.[6,12,13] So our study collected the details of above factors. The collected/lifted water from the sources were stored in PVC tanks (78.6%), Concrete tanks (13.4%) and in vessels (8.2%). Though PVC tanks are believed to be protective our study found that it was not protective (RR=1.88, 95% CI 0.60-5.80, P=0.23). Before immediate use water is stored in metallic vessels (70.3%), earthen pots or plastic buckets in kitchen. Compared to other storage methods, the storage in metallic vessel have got some protective association (RR=0.95, P=0.87) which was not significant.

At the point of use 95% practiced the physical method - boiling of water as treatment. Compare to others (17.6%) the incidence of WBD were less in these households (13.3%)(RR =0.86, P=0.45). Though not cost effective the boiling was an effective method of house hold disinfection, in our study found no significant association with WBD which give the clue that in most cases of WBD the people may getting infection from out side sources (Water, Food)[5,20]. Since due to work, educational related activities majority were spending most of their time out side their home, which may be the possible explanation. 34% of our subjects were students who spent most of the time away from house.

There are several possible explanations for the lack of association observed between the indicators assessed and WBDs (Table 3, 4). Compared to increased bacterial indicators low outcome of WBD may be attribute due to the high literacy rate in the area (99%), increased hygienic practices among the members like storage, boiling practices before consumption along with hand washing practices which prevent further contamination with pathogenic microbes. Meta analysis reported that hand washing with soap at critical points (before eating, after defecating and before handling food); improved sanitation and point of use water treatment are three most effective interventions which reduce the risks 37%, 34% and 29%.[20] Other possibilities are rather than household sources people are acquiring more infections from out side sources including water, food. Supporting this a previous study from the state reported that those children eating out side, and not washing hands have higher risk of WBD (OR=1.6, OR=2.3).[21] Nutritional status, immunologic

status, and genetic factors of a person also play a large role in determining disease outcome. First, not all WBD pathogens are transmitted exclusively via water. The bacterial, viral, and protozoan agents of WBD can also be transmitted by food, fomites, personal contact, and in some cases via droplets.[12] These points may be the explanation for the poor association of sanitary conditions of the house hold water sources /hygienic practices with WBD incidence in our study or a study with large sample size may give results with good statistical significances. As reported by many studies from developing countries our study also found that the relation between water quality at the source and WBD were lower than sanitation and treatment at point of use.[4,6,7,12]

Our study has got following limitations. Water quality may change frequently, but due to feasibility we could test water quality only thrice in the whole one year period. Many WBDs were sub clinical and may not perceived by the subjects; many sub clinical cases which didn't seek medical care may be under reported by the field workers. Our study was conducted in an area with high literacy and majority were using dug well as the source, so the findings may not be extrapolated in other rural areas of India with different literacy levels and different water sources.

Conclusion

Our study found that piped water supply was not available in the rural areas of the state and the dug wells were the major house hold water sources, which are included as improved water sources are not free from bacteriological contamination. The parameters which included in the criteria for a sanitary well may not always protect the consumers from the risks of WBD except the distance from septic tank. Safer household water storage and treatment is recommended to prevent WBDs, together with point-of-use water quality monitoring. Further studies with large sample size are necessary to create more precise ways of studying the role of water in the transmission of WBD especially in resource-limited settings.

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