Original Article

Water quality, sanitation, and hygiene among the tribal community residing in Jawadhi hills, Tamilnadu: An observational study from Southern India

Arunava Saha[1], Kusum V. Moray[1], Daniel Devadason[1], Barnabas Samuel[1], Sanjana Elizabeth Daniel[1], Lalthazuali[1], Joel Vasanth Peter[1], Jubin Jamshed[1], Harigovind M R[1], Mahita Rebecca Manne[1], Pathula Anusha Evangeline[1], Roshni Silvia Alexander[1], Ruby Issaac[1], Senthil J. Kumar[2], Sheela Roy[2], Sirshendu Chaudhuri[1], Venkat Raghava Mohan[1]

[1]Department of Community Health and [2]The Wellcome Trust Research Laboratories, Christian Medical College, Vellore, India
Name of the Department and Institution to Which the Work Should be Attributed: Department of Community Health; Christian Medical College, Vellore

Abstract

Objectives: To assess the water, sanitation, and hygiene (WASH) practice among the tribal population of Tamil Nadu, India and to determine the physiochemical and bacteriological quality of drinking water at the principal source and at the households along with the household-level determinants of WASH practices. **Methods:** A door-to-door survey was conducted in 150 households, distributed across six villages of *Jawadhi* hills, a tribal area in the state of Tamil Nadu, India. Water samples were collected from the principal sources and a subset of households for assessing water quality. A composite scoring was formulated to determine the overall WASH practices. **Results:** Overall, a poor WASH score (≤4) was found in 103 (68.7%; 95% CI: 60.7, 75.6) households. The majority (96.7%) of the household water samples showed the presence of fecal coliforms. Poor WASH score was uniformly distributed across the villages. Low per capita income (≤1000 INR) was strongly associated with the poor WASH score (Adjusted OR 2.4; 95% CI: 1.04, 5.7). The per capita income had a strong negative association with the high fecal coliform count (Adjusted OR 5.07; 95% CI: 1.08, 23.74). **Conclusions:** We conclude that WASH-related practices among the tribal population of Tamil Nadu is not acceptable. The lack of administrative function and poor economic conditions are the likely causes attributed to the poor WASH conditions and drinking water quality. Urgent action from the stakeholders is the need of the hour to improve the water quality and living standards of such marginalized populations.

Keywords: Determinants, hygiene, sanitation (WASH), water, water quality

Address for correspondence: Dr. Sirshendu Chaudhuri,
ICMR- National Institute of Epidemiology,
Chennai - 77, Tamil Nadu, India.
E-mail: sirshendusisu@gmail.com

Received: 24-07-2020 **Revised:** 17-09-2020
Accepted: 28-09-2020 **Published:** 30-11-2020

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_1519_20

Introduction

Safe water, sanitation, and hygiene (WASH) have remained as a major global concern over the recent years. WASH is a composite measurement, mostly determined by the availability

How to cite this article: Saha A, Moray KV, Devadason D, Samuel B, Daniel SE, Lalthazuali, *et al*. Water quality, sanitation, and hygiene among the tribal community residing in Jawadhi hills, Tamilnadu: An observational study from Southern India. J Family Med Prim Care 2020;9:5711-8.

of safe drinking water, safely managed sanitation facility, and provision for basic hand-washing facilities.[1] Inadequate access to such facilities can directly contribute to diarrheal illnesses, helminthic infections, eye infections, skin infection, pneumonia, and childhood malnutrition.[2-5]

The present situation of lack of WASH indices across the globe is worrisome.[6] Every one out of four people in the world lack access to safe drinking water, while only two out of four people use safely managed sanitation services. The value varies widely across different geographic or economic regions. Such variations are glaringly visible in the Asian and African countries.[7] Regional variations also exist within a country. For instance, while more than 90% of the urban population in India use safe water, the proportion comes down to 50% for the rural population.[1] Such prominent disparities exist in the availability of safe sanitation facilities as well. The World Bank data shows that almost 40% of people in the country currently practice open defecation—the rate being 50% in rural areas.[1] This is far from the target set in the Sustainable Development Goals (SDG) for open defecation by 2030.[8] This alone causes an estimated economic loss of 53.8 billion USD in a year in the country.[1]

While the indicators related to WASH are improving gradually, there is not much known about the tribal regions in India. The tribal population contributes to more than 8% of India's total population and is traditionally less developed than the non-tribal population due to various reasons like geographic barriers, and sociopolitical conditions.[9,10] Noticeably, the prevalence of communicable diseases is reportedly high in various tribal population in India.[11] This could be attributed to the poor WASH conditions in such areas. However, preliminary data WASH indicators among these populations are lacking. With this background, our study aimed to assess the water, sanitation, and hygiene (WASH) practices of tribal people, examine the drinking water quality at the principal source and at households, and to identify the household-level determinants of WASH practices and drinking water quality.

Subjects and Methods

Study design: A community-based cross-sectional study.

Study period: The study was conducted between August 2015 and September 2015.

Study Setting: The study was conducted in the hamlets (small villages) of the tribal area of *Jawadhi* hills, spread over the *Vellore* and *Tiruvannamalai* districts of Tamil Nadu, one of the southern states in India. *Jawadhi* hills, mostly having forest areas, consist of 12 panchayats and 229 hamlets and is characterized by a low population density, poor literacy rate (Overall 48%), and poor health indicators.[1] The majority (98%) of the permanent residents of this area belong to the indigenous tribal community called "*Malayalee*" tribes and mostly live on the natural resources available in this area.[3]

Sample size and Selection of participants: The sample size was calculated to be 150 households, considering the prevalence of poor water and sanitation practices as $P = 50\%$,[4] with a design effect of 1.5, a relative precision of 20%, and an alpha error of 5%.

A two-stage cluster sampling was done in the "Veerapanur" panchayat (purposively selected) which has 20 hamlets. Six hamlets were selected [Figure 1] randomly from the list. In each hamlet, 25 households were selected by systematic random sampling. A total of 150 households were included in the study.

Participants: Adults who were primarily responsible for water collection and storage in a household were chosen as respondents.

Data collection: A structured, pilot-tested, interviewer-administered questionnaire in the local vernacular was administered to the participants by the investigators after obtaining the informed consent. Household-level sociodemographic data and information pertaining to WASH were collected from the participants. A field worker trained in collecting water samples accompanied the study team for water sample collection. Drinking water samples were collected from 10 randomly selected households from each hamlet. One sample from each selected household was collected in sterile containers and transported to the Wellcome Trust Research Laboratory in CMC Vellore in ice-packed boxes at 2–8°C with an average transport time of two hours from the point of collection. Water quality was assessed in terms of pH, total dissolved solids (TDS) (using standardized instruments), chlorides, nitrates (using standardized kits), and fecal coliform counts after incubating in MacConkey agar medium (for a maximum period of 48 hours).

Definition of the outcome and the predictor variables

WASH score: We formulated a WASH score based on the reported practice of water handling, sanitation, and hygiene of the interviewer. The score was used as an indicator of the overall hygiene and sanitation practices prevalent in a household. Components of the scoring system are described in Table 1.

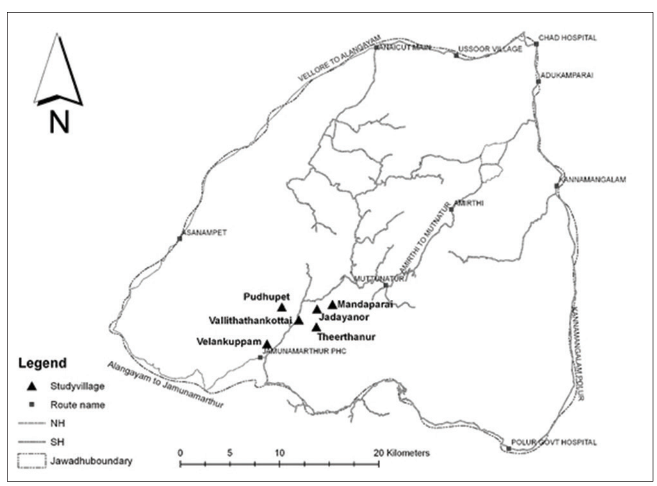

Figure 1 : Distribution of the study hamlets in relation to motorable road

Table 1: Components of WASH Score

Components of the score	Items under each component	Score
Drinking water	Method of water purification	
	Present	1
	None	0
	Covering of stored drinking water	
	Present	1
	No covering	0
	Drawing water using a dipper/separate allocated vessel/can with tap	
	Present	1
	None	0
Sanitation	Type of latrine used	
	Improved (WHO-UNICEF JMP[1])	1
	Unimproved/Open field defecation	0
Hygiene	Washing hands	
	After toilet	0.25
	Before preparing food	0.25
	Before feeding children	0.25
	Before eating	0.25
	Usage of soap	
	Never	0
	Sometimes	1
	Always	2
	Bathing frequency	
	Bathing once daily or more	1
	Bathing less frequently	0
	Total maximum score	8

Minimum and maximum possible WASH scores for a household were 0 and 8, respectively. For convenience, we took the median score as a cut-off, details of which has been provided in the results section.

Drinking water quality: WHO defines safely managed drinking water as water which is accessible within the premises, is available when needed and is free of contamination. However, for the present study, we considered only the bacteriological quality for assessing drinking water quality at the household level. For analysis purpose, a fecal coliform count of ≤10 colony-forming units (CFU) per 100 ml was considered as acceptable.

Predictor variables: Source to household network distance was estimated by measuring the approximate shortest path distance between the two points. The socioeconomic scale (SES) was measured by the updated "BG Prasad scale" for the year 2014.[12] The scale is based on per capita income in Indian Rupee (INR) per month of a household. The type of house was categorized based on the type of roof, walls, and floor. A house with concrete roof, wall, and the floor was considered as "pukka" house, whereas a house with all the walls and floor made up of mud and thatched roof was considered as "Kuccha" house. A house consists of features of both "pukka" and "kutcha" house was considered as "mixed" house. A respondent was considered "literate" if he/she reported that they could read and write and understanding at least one language.

Data entry and Statistical Analysis: Data entry was done in "EpiData 3.0" (The EpiData Association, Odense, Denmark) and statistical analysis was done in "Statistical Package for the Social Sciences (SPSS) version 20" for Windows (IBM Corp., Armonk, New York, 2010). The WASH-related practice was expressed in proportions with 95% confidence interval (CI). "Chi-square test" or "Fischer's Exact test" was done to detect differences between proportions. Continuous variables were expressed with mean and median as appropriate with standard deviation (SD) and interquartile range (IQR). "Kruskal–Wallis test" was applied to check the differences in the median values across the hamlets. Water quality was expressed in proportion according to the standardized cut-off for different parameters. Multivariate logistic regression models were done to predict the risk factors associated with poor WASH score and poor drinking water quality after adjusting for the clustering effect by "Generalised estimating equation" (GEE) and were considered significant if "α" < 0.05.

Ethics Committee clearance: The study was approved by the institutional review board where the study was conducted. (Ref- 11407[Retro] dated 27/06/2018) Informed consent was obtained from all the study participants.

Results: A total of 150 households were selected for the study from six hamlets. All those who were approached gave consent to participate. Table 2 summarizes the household characteristics of the participants. Most of the respondents were female (77.3%; n = 116), young to middle-aged (IQR 25–46 years), and illiterate (74.7%). Majority of the households belonged to poor socioeconomic background.

For drinking water, most of the households (88%; n = 132) depended on public sources like government-supplied public taps, borewells and tubewells, with a few exceptions (12%; n = 18) who relied on sources within their household premises. [Table 3]

Household characteristics related to WASH: Distance between the households and the principal source of drinking water significantly varied ($p < 0.05$; Kruskal–Wallis test) across the clusters. [Figure 2a]. The estimated median distance was 50 meters (IQR- 10 to 100 meter). The households used 20 litres of water for all purposes on average (IQR- 14–30 litres); however, we did not get a significant variation ($p > 0.05$, Kruskal–Wallis test) across the clusters [Figure 2b]. Most of the households stored drinking water in traditional wide-mouthed metal or plastic containers (97.3%), without purification (57.3%) prior to drinking, and withdrew water with the help of a vessel by dipping their hand inside (98.6%) [Table 3]. Open-air defecation remained almost a universal practice in this area.

WASH score: The mean household WASH score was 4.17 (SD 1.0) with 68.7% (n = 103) households having poor WASH scores (<=4). Figure 3 depicts the variation in the mean WASH score across the hamlets; however, it was not statistically significant ($p > 0.05$; Kruskal–Wallis test).

Predictors of poor WASH score: The multivariate model finds poor income (<1000 INR/capita/month) as a strong predictor for poor WASH score. [Table 4] We found people living in "pukka" or "semi-pukka" houses a weak predictor for poor WASH score than people living in "kutcha" houses ($p = 0.06$). Variables like "age of the respondent > 30 years" (OR-0.81; 95% CI: 0.4-1.63), "illiterate respondent" (OR-1.02; 95% CI: 0.46–2.24), and "more than 4 household members" (OR-0.83; 95% CI: 0.43-1.67) did not show any association in univariate analysis.

Water quality analysis: We analysed selected physical, chemical, and bacteriological parameters of the drinking water [Table 5]. The bacteriological parameter was unacceptable in most of the samples.

Table 2: Description of the household characteristics (*n*=150)

Household characteristics	Frequency
Mean age of the respondents in years (SD)	36.8 (13.7)
Literacy status of the respondents	
Literate (%)	38 (25.3)
Illiterate (%)	112 (74.7)
Monthly median income/capita (IQR)	500 (333-1000)
Mean number of household members (IQR)	4.5 (3.0-6.0)
Households carrying BPL card*	108 (72%)
Type of house (%)	
Kuccha	63 (42)
Mixed	37 (24.7)
Pukka	50 (33.3)
SES (%) (BG Prasad, 2014) (12)	
Upper middle	5 (3.3)
Middle	10 (6.7)
Lower middle	27 (18.0)
Lower	108 (72.0)

*A household belongs to BPL (Below poverty line) if annual income <27,000 INR

The sampled drinking water sources were four (40%) overhead tanks, two hand pumps (20%), bore wells (20%), and dug wells (20%) each. Of these, one overhead tank and one bore well showed nil coliform.

At the household level, low per capita income is strongly associated with poor water quality in terms of coliform load [Table 6]. Variables like "age of the respondent > 30 years" (OR-0.73; 95% CI: 0.17–3.1), "illiterate respondent" (OR-1.0; 95% CI: 0.23–4.31), "more than 4 household members" (OR 0.84; 95% CI: 0.23–3.02), "highest education in the family" (OR 0.86; 95% CI: 0.16–4.66), and "household with poor WASH

Table 3: Summary characteristics of WASH (*n*=150)

Drinking water characteristics	Frequency (%)
Source of drinking water	
Piped water within premises	18 (12.0)
Borewell/Tubewell	78 (52)
Public tap	53 (35.3)
Surface water	1 (0.7)
Storage	
Metal pots	131 (87.3)
Plastic vessels	15 (10.0)
Earthen pots	4 (2.7)
Water stored in covered containers	
Yes	144 (96.0)
No	6 (4.0)
Purification at household level	
Occasional boiling	39 (26.0)
Filtration	25 (16.7)
None	86 (57.3)
Drawing water from storage container	
Tumbler/ Dedicated vessel*	148 (98.6)
Can with tap	1 (0.7)
Other	1 (0.7)
Sanitation	
Defecation practice	
Open field	149 (99.3)
Latrine	1 (0.7)
Hygiene	
Hand wash after toilet	
Yes	146 (97.3)
No	4 (2.7)
Hand wash before food preparation	
Yes	142 (94.7)
No	8 (5.3)
Hand wash before eating	
Yes	147 (98.0)
No	3 (2.0)
Frequency of bathing	
>Once a day	9 (6.0)
Once a day	68 (45.3)
Thrice a week	61 (40.7)
Less than thrice a week	12 (8.0)
Usage of soap	
Never	11 (7.3)
Sometimes	80 (53.3)
Always	59 (39.3)

*Reported using a smaller vessel/tumbler to draw water from storage vessel

Table 4: Univariate and multivariate analysis for assessing determinants for poor WASH status

Variables	Frequency (%) in poor WASH group	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*P*
Type of house				
Pukka/semi pukka	65 (74.7)	1.9 (1.0-3.9)	1.94 (0.95-3.98)	0.06
Kuccha	38 (60.3)			
Highest education in the household				
Completed 12th standard	87 (71.3)	1.9 (0.8-4.3)	0.95 (0.37-2.42)	0.92
Below 12th standard	16 (57.1)			
Occupation of head of the household				
Mostly field work	98 (71.0)	3.43 (1.03-11.47)	0.9 (0.22-3.7)	0.88
Others	5 (41.7)			
Per capita income in INR				
Low (≤1000)	89 (72.4)	2.4 (1.04-5.7)	2.43 (1.02-5.79)	0.04
High (>1000)	14 (51.9)			

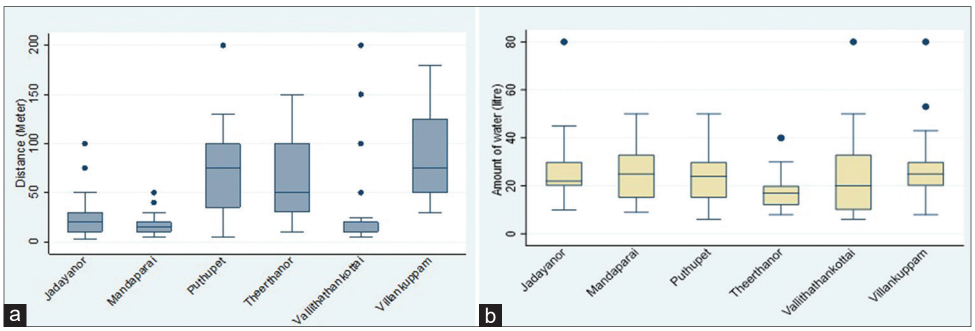

Figure 2: a: Cluster-wise distribution of principal water source to household distance. b: Cluster-wise distribution of per capita water use for all purposes

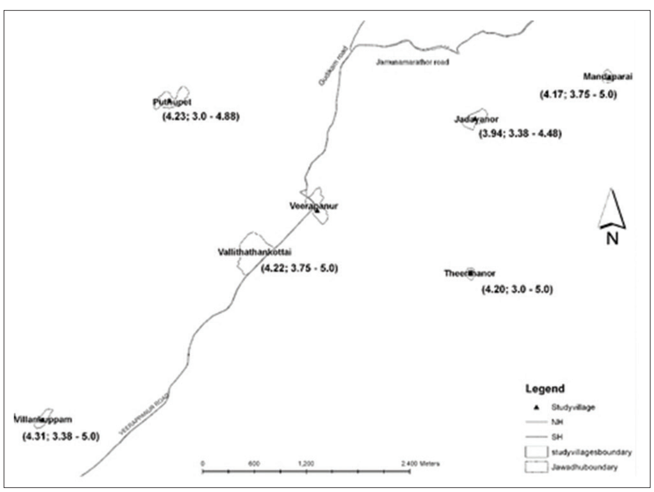

Figure 3: Distribution of WASH score in different study hamlets

score (<4)" (OR 1.21; 95% CI: 0.31–4.69) did not show any significant association in univariate analysis.

Discussion and Conclusions

This study provides comprehensive findings on water quality, sanitation, and hygiene among the vulnerable tribal population known for its geographical and socioeconomic barriers. Roughly two-thirds of this population showed poor knowledge and practice as indicated by the overall WASH score. Sanitation, a component of the WASH score, was identified as the major problem. Open defecation was almost a universal practice in this area. However, the other components had a mixed response of poor practice and an acceptable practice.

Almost half of the drinking water sources are directly under the government service; however, water supply from these sources are mostly inadequate and infrequent. Anecdotal evidence states that this district goes dry during the summer season, and therefore, the quantity and frequency of water supply varies in different seasons.[13,14] Studies from other parts of the country reported similar variation.[15-17] Infrequent water supply would compel the local population to store water for longer duration which eventually leads to high bacterial load in the drinking water. In addition to such administrative factors, unavailability of provisions for proper water handling, hand hygiene, and sanitation facility due to poor socioeconomic status could have influence the WASH score. None of the households had a safely managed drinking water source as defined by JMP, 2017.[1] The World bank data for 2015 showed that 49% of the rural population in India used safely managed drinking water source. Hence, our study shows that tribal areas are worse off than the rural households in this aspect. Surprisingly, the present finding is far from the 2017 report of Tamil Nadu state government,[18] which states that more than 99% of the households in Vellore district have safe drinking water source from an improved source, while the figure is 93% according to NFHS-4.[19] Nevertheless,

Table 5: Water quality at the sources and households

Parameters	Recommended limits[13]	Source (*n*=10)		Household (*n*=60)	
Physical		Within acceptable limits (%)	Not acceptable (%)	Within acceptable limits (%)	Not acceptable (%)
pH	6.5-8.5	10 (100.0)	0 (0)	60 (100)	0 (0)
TDS	<600 ppm*	4 (40.0)	6 (60.0)	20 (33.3)	40 (66.7)
Chemical					
Nitrate	<50 ppm	10 (100.0)	0 (0)	60 (100)	0 (0)
Free chlorine		0 (0)	10 (100)	0 (0)	60 (100)
Bacteriological					
Faecal coliform	≤10 CFU/100 ml†	5 (50)	5 (50)	12 (20)	48 (80)

*Parts per million. †For analysis purpose, 10 CFU was taken as a cut-off as per the flexibility prescribed by WHO for developing countries

Table 6: Univariate and multivariate analyses of drinking water quality (Fecal coliform ≥10 per 100 ml) at the household level (*n*=60)

Variables	Frequency (%) of households with high fecal coliform (≥10 per 100 ml)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*P*
Type of house				
Pukka/semi pukka	31 (75.6)	0.36 (0.07-1.86)	2.03 (0.5-8.23)	0.3
Kuccha	17 (89.5)			
Per capita income per month (INR)				
Low (≤1000)	41 (85.4)	4.18 (1.03-16.96)	5.07 (1.08-23.74)	0.03
High (>1000)	7 (58.3)			
Distance of drinking water source from household				
≥100 metres*	8 (100)	1.3 (1.12-1.51)	0.3 (0.05-1.8)	0.19
<100 metres	40 (76.9)			
Type of storage container				
Earthen or plastic	8 (100)	1.3 (1.12-1.51)		
Metal	40 (76.9)			
Method of purification				
None	32 (88.9)	4.0 (1.05-15.3)	1.04 (0.25-4.31)	0.95
Any method	16 (66.7)			
Covering of storage container				
No	2 (100)	1.26 (1.11-1.44)		
Yes	46 (79.3)			

*1 metre=3.28 feet

in our study, nearly half the households get drinking water from a piped source which is substantially better than what was reported[20] in the nearby district where only 2% of the tribal population were getting drinking water from the piped water source.

The microbiological analysis of the drinking water was undoubtedly alarming as none of the samples from the households had an acceptable bacteriological quality. In addition to our finding of high contamination in the source samples, the other possible reasons behind high coliform count at the household level include long "source to household distance," "improper storage," "infrequent water purification," the common "practice of open defecation," and "poor hygiene practice" as evident from our findings. Studies of other low- and middle-income countries also reported a high fecal coliform count in drinking water.[21] It was reported that high contamination could be due to improper transport, storage, and handling of water from source, environmental, and behavioral factors.[22-24] We expect the microbiological quality to vary in different seasons. The present study was done in the winter season; and therefore, we can expect even higher coliform count during summer and monsoon season.[25]

Our study has multi-level implications. First, it is one of the very few studies in India that has identified the WASH standard and drinking water quality in an indigenous tribal population that was at stake. Besides identifying the base-line WASH standard and drinking water quality, which may be associated with various diarrheal and non-diarrheal communicable diseases[26-29]; the study also unveiled other potential risks for the study population like wage loss due to time spent in fetching water and various social hazards for women and children who fetch water.[30,31] Therefore, the present study unfolds the opportunity to develop further research questions in this area including identifying the efficacy of various strategies to improve the WASH and drinking water standards. Additionally, the primary care physicians working in the tribal or hard-to-reach areas must be aware of the role of poor WASH practices while treating health conditions that may be related to it. Repeated context-specific but scientifically valid health education by the primary care physicians may improve the condition.

Therefore, the key findings of our study include water quality, sanitation, and hygiene practices in this tribal area are substantially poor which is often associated with the low per capita income; household members, especially the women, are forced to spend considerable time to fetch drinking water from distant places; drinking water at the household level is almost universally infected with coliforms.

Findings from our study indicate that much work is needed to improve the water quality, sanitation, and hygiene. The findings are particularly valuable for developing nations where systematic water quality monitoring is lacking mainly because of resource constraints.[32] Besides improving the supervision and monitoring of the existing systems, we strongly recommend adopting culturally acceptable educational models[33,34] to change WASH-related behavior at the household level. These models should incorporate cost-effective strategies like regularizing household-level water treatment and improving water storage facilities to improve water quality.[35] Such models can be implemented by local health agencies, educational institutions, and nonprofit organizations along with the general administration.

Limitation: We could not assess the water quality for all households due to lack of resources. A higher number of water samples might have detected the determinants precisely. The WASH score was devised by our team and is not validated yet.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Key messages

- WASH parameters are substantially poor in the tribal area.
- Poor WASH score is uniformly distributed across the tribal clusters.
- High proportion of water samples are contaminated with fecal coliforms.
- Nearly, all tribal populations go for open defecation.
- Finding suggests existence of administrative failure in implementing programs.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organization, UNICEF. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. 2017.
2. Ziegelbauer K, Speich B, Mäusezahl D, Bos R, Keiser J, Utzinger J. Effect of sanitation on soil-transmitted helminth infection: Systematic review and meta-analysis. PLoS Med 2012;9:e1001162.
3. Caruso BA, Sevilimedu V, Fung IC-H, Patkar A, Baker KK. Gender disparities in water, sanitation, and global health. Lancet 2015;386:650–1.
4. Engell RE, Lim SS. Does clean water matter? An updated meta-analysis of water supply and sanitation interventions and diarrhoeal diseases. Lancet 2013;381:S44.
5. Pickering AJ, Njenga SM, Steinbaum L, Swarthout J, Lin A, Arnold BF, *et al.* Effects of single and integrated water, sanitation, handwashing, and nutrition interventions on child soil-transmitted helminth and Giardia infections: A cluster-randomized controlled trial in rural Kenya. PLoS Med 2019;16:e1002841.
6. Burki T. Prioritising clean water and sanitation. Lancet Infect Dis 2015;15:153–4.
7. Sanitation [Internet]. World Bank. [cited 2018 Mar 02]. Available from: http://www.worldbank.org/en/topic/sanitation.
8. Martin. Water and Sanitation [Internet]. United Nations Sustainable Development. [cited 2019 Sep 03]. Available from: https://www.un.org/sustainabledevelopment/water-and-sanitation/.
9. Hays J. Tribal People in India | Facts and Details [Internet]. [cited 2018 Mar 07]. Available from: http://factsanddetails.com/india/Minorities_Castes_and_Regions_in_India/sub7_4h/entry-4216.html.
10. Ministry of Tribal Affairs. Statistical Profile of Scheduled Tribes in India 2013 [Internet]. Government of India; 2013. Available from: https://www.tribal.nic.in/ST/StatisticalProfileofSTs2013.pdf.
11. Negi DP, Singh DMM. Tribal health and health care beliefs in India: A systematic Review. International Journal of Research in Social Sciences 2018;8:9.
12. Mangal A, Kumar V, Panesar S, Talwar R, Raut D, Singh S. Updated BG Prasad socioeconomic classification, 2014: A commentary. Indian J Public Health 2015;59:42-4.
13. Cissé G. Food-borne and water-borne diseases under climate change in low- and middle-income countries: Further efforts needed for reducing environmental health exposure risks. Acta Trop 2019;194:181–8.
14. Alarcon Falconi TM, Kulinkina AV, Mohan VR, Francis MR, Kattula D, Sarkar R, *et al.* Quantifying tap-to-household water quality deterioration in urban communities in Vellore, India: The impact of spatial assumptions. Int J Hyg Environ Health 2017;220:29–36.
15. Bhunia R, Ramakrishnan R, Hutin Y, Gupte MD. Cholera outbreak secondary to contaminated pipe water in an urban area, West Bengal, India, 2006. Indian J Gastroenterol 2009;28:62–4.
16. Kumpel E, Nelson KL. Intermittent water supply: Prevalence, practice, and microbial water quality. Environ Sci Technol 2016;50:542–53.
17. Brick T, Primrose B, Chandrasekhar R, Roy S, Muliyil J, Kang G. Water contamination in urban south India: Household storage practices and their implications for water safety and enteric infections. Int J Hyg Environ Health 2004;207:473–80.
18. Government of Tamil Nadu. State Planning

Commission [Internet]. 2017 [cited 2018 Sep 28]. Available from: http://www.spc.tn.gov.in/tnhdr2017.html.

19. Ministry of Health and Family Welfare. Distric Fact Sheet, Vellore, Tamil Nadu [Internet]. 2016 [cited 2018 Sep 28]. Available from: http://rchiips.org/nfhs/FCTS/TN/TN_FactSheet_605_Vellore.pdf.
20. Reddy BV, Kusuma YS, Pandav CS, Goswami AK, Krishnan A. Water and sanitation hygiene practices for under-five children among households of Sugali tribe of Chittoor District, Andhra Pradesh, India. J Environ Public Health 2017 [cited 2018 Jun 18];2017. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5470013/.
21. Bain R, Cronk R, Wright J, Yang H, Slaymaker T, Bartram J. Fecal contamination of drinking-water in low- and middle-income countries: A systematic review and meta-analysis. PLoS Med 2014;11:e1001644.
22. Kattula D, Francis MR, Kulinkina A, Sarkar R, Mohan VR, Babji S, *et al*. Environmental predictors of diarrhoeal infection for rural and urban communities in south India in children and adults. Epidemiol Infect 2015;143:3036–47.
23. Wright J, Gundry S, Conroy R. Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. Trop Med Int Health 2004;9:106–17.
24. Eshcol J, Mahapatra P, Keshapagu S. Is fecal contamination of drinking water after collection associated with household water handling and hygiene practices? A study of urban slum households in Hyderabad, India. J Water Health 2009;7:145–54.
25. Kostyla C, Bain R, Cronk R, Bartram J. Seasonal variation of fecal contamination in drinking water sources in developing countries: A systematic review. Sci Total Environ 2015;514:333–43.
26. Travers A, Strasser S, Palmer SL, Stauber C. The added value of water, sanitation, and hygiene interventions to mass drug administration for reducing the prevalence of trachoma: A systematic review examining. J Environ Public Health 2013;2013:682093. doi: 10.1155/2013/682093.
27. Fewtrell L, Colford JM. Water, sanitation and hygiene in developing countries: Interventions and diarrhoea--A review. Water Sci Technol 2005;52:133–42.
28. Strunz EC, Addiss DG, Stocks ME, Ogden S, Utzinger J, Freeman MC. Water, sanitation, hygiene, and soil-transmitted helminth infection: A systematic review and meta-analysis. PLoS Med 2014;11:e1001620.
29. Gera T, Shah D, Sachdev HS. Impact of water, sanitation and hygiene interventions on growth, non-diarrheal morbidity and mortality in children residing in low- and middle-income countries: A systematic review. Indian Pediatr 2018;55:381–93.
30. Graham JP, Hirai M, Kim SS. An analysis of water collection labor among women and children in 24 Sub-Saharan African countries. PLoS One [Internet]. 2016 Jun 1 [cited 2018 Aug 19];11. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4889070/.
31. Dutta S, Sinha I, Parashar A. Dalit women and water: Availability, access and discrimination in rural India. Journal of Social Inclusion Studies 2018;4:62–79.
32. Crocker J, Bartram J. Comparison and cost analysis of drinking water quality monitoring requirements versus practice in seven developing countries. Int J Environ Res Public Health 2014;11:7333–46.
33. Dreibelbis R, Winch PJ, Leontsini E, Hulland KR, Ram PK, Unicomb L, *et al.* The Integrated Behavioural Model for Water, Sanitation, and Hygiene: A systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure-restricted settings. BMC Public Health 2013;13:1015.
34. Curtis VA, Danquah LO, Aunger RV. Planned, motivated and habitual hygiene behaviour: An eleven country review. Health Educ Res 2009;24:655–73.
35. Mintz ED, Reiff FM, Tauxe RV. Safe water treatment and storage in the home: A practical new strategy to prevent waterborne disease. JAMA 1995;273:948–53.