Original Research Article

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20163934

Drinking water practices and sanitation in slums of Visakhapatnam, Andhra Pradesh a developing smart city in India

Karun Sandeep Veesa¹, Chandra Shekhar Dimmala², Obed John Heber Antipas¹, Venkata Raghava Mohan¹, Sushil Mathew John³*

Received: 06 September 2016 **Accepted:** 03 October 2016

*Correspondence:

Dr. Sushil Mathew John,

E-mail: rikkisush@cmcvellore.ac.in

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ABSTRACT

Background: Inadequate water quality and sanitation contribute to the transmission of faeco- orally transmitted diseases.

Methods: This community based cross sectional study assessed drinking water, sanitation and factors associated with reported 2 week recall diarrhea burden among under-five children in slums. 220 households with under-five children were selected across 14 slums of Zone-6, Visakhapatnam by cluster sampling. A WHO drinking water and sanitation questionnaire was used. Hydrogen sulfide (H₂S) water quality test was performed at point of source and use. Data subjected to bivariate and multivariate logistic regression analysis.

Results: Mean age of mothers and children were 24.4 (SD 3) years and 28.3 (SD 14.5) months. Study finds 33% (20/60) source samples and 34% (75/220) point of use samples were contaminated. Reported diarrhoea episodes was 14% (31/220) (95% CI 9.4 - 18.5%). All public water system samples were contamination free. Higher contamination rates were observed in untreated private water systems. Despite 41.4% (91/220) households using boiling or filtration methods, 26.4% (24/91) of these samples were contaminated. Factors significantly associated with reported diarrhoea were, low SES (OR 2.3, 95% CI 1.0 - 5.5), unsafe defecation practice (OR 2.2, 95% CI 1.0 - 4.9) and age less than 2 years (OR 2.4, 95% CI 1.0 - 5.5).

Conclusions: All treated public water supplied by Municipal Corporation was contamination free and use of this supply should be encouraged. Safe child defecation practices and effective household water treatment methods should be promoted in slums.

Keywords: Drinking water, Diarrhoea, H₂S water quality test, Sanitation, Urban slums

INTRODUCTION

It is evident that safe drinking water and sanitation are significant public health challenges across the globe. The United Nations (UN) has declared the access to safe drinking water and sanitation as a basic human right in year 2010. Despite this, inadequate drinking water and poor sanitation among the developing nations brought about 842000 deaths in 2012, which accounted for 1.5%

of the total disease burden and 58% of all diarrhoeal diseases, where by an improved practices 5.5% of these deaths could have averted in the under-five children age group.³

Globally, raised industrialization and urbanization in 20th century gave rise to a 33% of the developing world being an urban population and a significant rise in the population living in slums, which raised a disadvantaged

¹Department of Community Medicine, Christian Medical College, Vellore, Tamil Nadu, India

²Department of Community Medicine, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India

³Low Cost Effective Care Unit, Christian Medical College, Vellore, Tamil Nadu, India

population with many health inequalities in comparison with urban non-slum residents.⁴ This has been identified as a rise of an urban penalty and growing health inequalities among developing nations.⁵ Diverse factors such as poor economic status, illiteracy, improper housing, and lack of governance are being held responsible for adverse environmental conditions in slums. Moreover, open defecation practice poses a serious threat, where India accounts for 90% of people in South Asia and 59% of people in the world who practice open defecation.⁶

A recent assessment, in 2015, of progress with respect to the millennium development goals (MDGs) showed significant progress in improved drinking water access by halving the proportion of global population, who had inadequate access to safe drinking water compared to 1990. However, the target for improved sanitation has been lagging behind with 700 million people across the world yet to be reached. To sustain its progress, further WHO/UNICEF joint monitoring program (JMP) has put forward Post-2015 WASH targets and indicators to attain universal coverage of safe practices by 2030.8 The 'Clean India Mission' (Swachh Bharat Abhiyan) started in India in 2014, to promote safe water and sanitation practices in society by 2019 is an initiative towards achieving the targets.⁹ Also other related initiatives were laid down for development of smart cities across the nation. 10 JMP defined improved water source as one that, by proper construction or through appropriate intervention, source is protected from external contamination, in particular from faecal matter contamination and improved sanitation as one that provides hygienic separation of excreta from human contact.⁷

This study was conducted in Visakhapatnam, Andhra Pradesh one among the developing smart cities, which has recorded the highest number of slum households to the urban households in census 2011, standing at 44.1% among all the million plus population cities in India. 11,12 Under these circumstances of rapid urbanization and increased informal slum settlements, this study aims to assess drinking water treatment, contamination rates and sanitation practices in slum households among children less than five years of age, and their association with reported diarrheal illness in a two week recall period.

METHODS

Study area

The study was conducted in slums of Visakhapatnam, an urban area located on the east coast of India with a population of 1,730,320 covering 681.96 Sq.km during census 2011. Area is divided into 72 wards that spread across six geographical zones (shown in Figure 1) and governed under Greater Visakhapatnam Municipal Corporation (GVMC). Present study confined to Zone-6 consisting of 93 urban slums distributed across 7 wards. The public water distribution system in the area is

administered by the GVMC. Besides there, there were several household (private) bore wells and open wells to meet the demand of drinking water in slums. The sources of public water supply were from three surface water reservoirs, namely Thatipudi, Raiawada and Yeleru reservoirs.

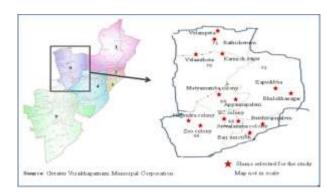


Figure 1: Map showing Greater Visakhapatnam Municipal Corporation and study slums selected from Zone – 6.

Study population

Mothers and children (aged 6-60 months) were taken from households with under five children in the slums. In case of more than one child in a household, the study child was selected randomly.

Sample size and household sampling

Going by a similar study that showed 54% household storage drinking water contamination using H_2S test in the slums of Delhi, a minimum sample size (n) = 220 was obtained after inclusion of cluster effect and 10% nonresponse rate. A cluster sampling method was applied to select 2 slums from each of the 7 wards of Zone-6 and then an average of 15 households was recruited from each slum. Finally, target households were picked by a systematic sampling by the assistance of accredited social health activist (ASHA) worker. The regional medical institute, Andhra Medical College (AMC) assisted in the conduct of this study by supporting field work and providing household information.

Collection of water samples for quality testing

Water samples were collected by a trained field worker from the point of source and point of use within the household. Collection of water samples at the point of sources were from public taps connected to local overhead tank, water drawn from a tanker truck, bore well outlets and open wells, however water samples from bottled or can water sources were not captured in the study. Samples were collected in a 20ml sterile vial (H₂S test vial) as per instructions of the test manufacturer (TARA Aqua check vial, Tara life Sustainability Solutions Pvt. Ltd) and precautions were taken to avoid

any external contamination by cautiously unsealing the vial cap and by holding the vial at an adequate distance from the source.¹⁴

Hydrogen sulfide (H_2S) water quality test

This test was chosen for its simplicity and feasibility in field studies. The water samples obtained were incubated between 15 to $45\,^{\circ}\text{C}$ and the results recorded after 48 hours. Presence or absence of H_2S producing pathogenic bacteria associated with a faecal contamination, which are primarily coliforms was detected. If H_2S producing bacteria were present in the water sample, there would be the production of H_2S gas, which reacted with iron in the media to form iron sulfide and gave a black precipitate in the tested sample, thus showed the presence of contamination. 15,16

Questionnaire and statistical analysis

The questionnaire used in this study was adapted from WHO drinking water and sanitation questionnaire.¹⁷ Components in the survey questionnaire were identified with demographic information, household economic status measured by modified Kuppuswamy scale, sources of drinking water, storage practices, household water treatment, sanitation practices and past two week reported diarrhoea episodes in children.¹⁸ Data entry was done using EPI-Info 7 and analysis by SPSS 16.0 (SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago). Descriptive statistics for demographic characteristics, drinking water and sanitation practices, multivariate logistic regression model was performed to identify the association between the risk factors and the outcome variable.

Study approval

The study was approved by the institutional ethics and research committee of Christian Medical College, Vellore. IRB Min No: 9238 dated 12.01.2015.

RESULTS

Demography

Mother and child were recruited as study subjects from each household in a slum. There were 44.5% (98/220) male and 55.5% (122/220) female children and majority of mothers, 90% (199/220) were in the age group of 21-30 years. Of the study population, 33.6% (74/220) mothers and 37.3% (82/220) fathers have reached secondary education. With respect to occupation of mothers, 7.3% (16/220) were unskilled daily wage workers, 2.7% (6/220) were involved in some kind of skilled work including one mother as a teacher and 90% (198/220) were house wives. As per modified Kuppuswamy scale of socio economic status (SES), 57.7% (127/220) of study population belong to low SES, 41.8% (92/220) middle SES and one household belong to

upper SES category. Of the study households, 48.6% (107/220) were nuclear families, 36.8% (81/220) joint families and 14.6% (32/220) extended families. At a household level, 29.5% (65/220) had one child, 58% (127/220) had two children and 12.5% (28/220) had more than two children.

Drinking water and sanitation practices

Of the study households, 76% (167/220) used public water supply (Public taps, Tanker truck and Public bore wells) and 24% (53/220) used private water supply (Private bore wells, Open wells and Bottle/Can water sources) as shown in Figure 2. Majority of households 94.5% (208/220) stored drinking water in steel jars and 5.5% (12/220) stored in bottles. Only 41.4% (91/220) households treated drinking water either by boiling 85% (77/91) or using home filters 15% (14/91) which included ceramic or carbon filters.

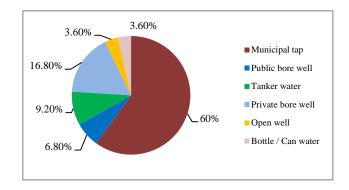


Figure 2: Primary sources of drinking water in slums among study population, N = 60.

Of the study households, 83.2% (183/220) had toilet facility in their house, 16.4% (36/220) went for open defecation and one (0.4%) household used public toilet facility. Among those who utilize household toilet facility, 3.8% (7/183) households shared the toilet facility with neighbourhood families. In this study, 75.5% (166/220) children defecate in latrine or toilet in the house and this was regarded as safe defecation practice and 24.6% (54/220) children defecate near open fields, drains and house premises which were considered as unsafe defecation practice.

Drinking water quality test

A total of 60 samples were collected from both public and private sources (excluding bottle water sources) and 220 samples from household storage containers. Of them, 33% (20/60) [95% CI (21.1% - 44.9%)] at point of source and 34% (75/220) [95% CI (27.74% - 40.26%)] from point of use samples had contamination, (shown in Figure 3, 4). Despite 41.4% households using boiling or filtration, 26.4% (24/91) samples were contaminated. Higher contamination rates were recorded in household water samples from private water supply compared to public water supply.

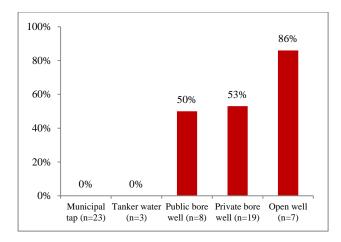


Figure 3: Contamination rates of 'point of source' water samples using H₂S test, N = 60.

Diarrhoea burden

Among 220 children enrolled in the study, 14% (31/220) [95% CI (9.4% - 18.6%] reported with diarrhea episodes in a past two weeks period, of them 58% (18/31) were males and 42% (13/31) were females. Table 1 and 2 shows demographic characteristics, drinking water and sanitation practices of study population and their association with diarrhoea burden. Predominantly slum households belonging to low SES category has showed a

significant association with the diarrhoea burden. It was found that 24.5% (54/220) children defecate in open grounds or nearby drains, and these unsafe defecation practices were significantly associated with diarrhoeal burden. The predictor variables that were found to be independently associated with diarrhoeal burden were low SES and unsafe child defecation practices.

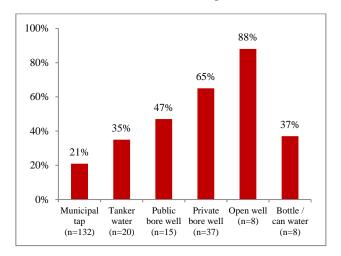


Figure 4: Contamination rates at 'point of use' water samples and its primary source, N=220.

Table 1: Demographic characteristics of study population and its association with reported diarrhoea burden in children.

Characteristics		Diarrhoea (+) n (%)	Diarrhoea (-) n (%)	OR (95% CI)	Chi-square p value
Gender	Boy	17 (17.3)	81 (82.7)	1.6 (0.7 - 3.4)	0.21
	Girl	14 (11.5)	108 (88.5)	1.0 (0.7 - 3.4)	
Age of children	< 2 years	19 (18.8)	82 (81.2)	2.0 (0.9 - 4.4)	0.06
	> 2 years	12 (10)	107 (90)	2.0 (0.7 - 4.4)	
Mothers education	Up to secondary education	26 (17)	128 (83)	2.4 (0.9 - 6.7)	0.06
	Above secondary education	5 (7.6)	61 (92.4)	2.4 (0.9 - 0.7)	
Mothers	Yes	4 (18)	18 (82)	1.4 (0.4 - 4.4)	0.56
occupation	No	27 (13.6)	171 (86.4)	1.4 (0.4 - 4.4)	
SES	Low	23 (18)	104 (82)	2.3 (1.0 - 5.5)	0.045
	Mid – High	8 (8.6)	85 (91.4)	2.3 (1.0 - 3.3)	
Family	Joint and Extended	18 (16)	95 (84)	1.3 (0.6 - 2.9)	0.42
	Nuclear	13 (12)	94 (88)	1.3 (0.0 - 2.9)	
Children in	> 1 child	19 (12.3)	136 (87.7)	0.6 (0.2 - 1.3)	0.22
house	1 child	12 (18.5)	53 (81.5)		
Size of house	1 room	1 (6.3)	15 (93.8)	0.3 (0.04 - 3.0)	0.70
	> 1 room	30 (14.7)	174 (85.3)	0.3 (0.04 - 3.0)	
Type of house	Kutcha, semi pucca	12 (16.7)	60 (83.3)	12(06 20)	0.44
	Pucca	19 (13)	129 (87)	1.3 (0.6 - 2.9)	

Table 2: Drinking water, sanitation practice of study population and its association with reported diarrhoea burden in children, N = 220.

Characteristics		Diarrhoea (+) n (%)	Diarrhoea (-) n (%)	OR (95% CI)	Chi-square p value
Source of drinking water	Private	9 (17)	44 (83)	1.3 (0.5 - 3.1)	0.48
	Public	22 (13)	145 (87)	1.5 (0.5 - 5.1)	
Household water treatment	Do not use	112 (87)	17 (13)	11(05 25)	0.64
	Use ^b	14 (15.4)	77 (84.6)	1.1 (0.5 - 2.5)	
Use of dipper (N=209) ^a	Do not use	18 (17.6)	84 (82.4)	1.0.(0.0	0.12
	Use	11 (10)	96 (90)	1.8 (0.8 - 4.1)	
Sanitation practice	Un improved	7 (19.4)	29 (80.6)	1.6 (0.6, 4.0)	0.31
	Improved	24 (13)	160 87)	1.6 (0.6 - 4.0)	
Child defecation practice ^c	Unsafe	12 (22)	42 (78)	2.2 (1.0 4.0)	0.048
	Safe	19 (11.4)	147 (88.6)	2.2 (1.0 - 4.9)	
Household drain	Open	20 (15)	114 (85)	11(05 26)	0.65
	Close	11 (13)	75 (87)	1.1 (0.5 - 2.6)	
Household waste disposal	Surroundings / In open drain	4 (9.3)	39 (90.7)	0.5 (0.1 1.7)	0.31
	Public disposal at designated area	27 (15.3)	150 (84.7)	0.5 (0.1 - 1.7)	

^a Out of 220, 11 (5%) households store drinking water in bottles and do not use dipper; ^b 91 (41.4%) households treat water either by boiling (85.7%) or by filtration (15.3%); ^c Child defecate in latrine or toilet in the house regarded as safe defecation practice and near open fields, drains and house premises considered as unsafe practice.

Table 3: Multivariate logistic regression analysis.

Characteristics		UA OR (95% CI)	A OR (95% CI)	Chi square p value
CEC antagory	Lower	2.3 (1.0 - 5.5)	2.9 (1.0 – 7.7)	0.03
SES category	Mid - Upper	2.3 (1.0 - 3.3)	2.9 (1.0 – 7.7)	0.03
Age of children	<2 years	2.0 (0.9 - 4.4)	2.4 (1.0 - 5.5)	0.03
	>2 years	2.0 (0.9 - 4.4)	2.4 (1.0 - 3.3)	0.03
Child defecation	Un-safe	2.2 (1.0 - 4.9)	10(08 45)	0.11
practice	Safe	2.2 (1.0 - 4.9)	1.9 (0.8 - 4.5)	0.11

Following the multivariate analysis, shown in Table 3, children less than 2 years of age also found to have a significant association with diarrhoea burden.

DISCUSSION

The present study evaluated the quality of drinking water from household samples and primary sources using H_2S method, which has been stated as a suitable test to carry out in resource poor settings. ^{15,16} There was no accessible standard quality test (such as Multiple tube fermentation or Total coliforms test) in the study area, which made the investigators to prefer a portable H_2S method for a field test.

This study found major contamination of sources is from untreated private water systems (86% open well and 53% hand or motor pumps). A study done by Anwar *et al* using a similar test in Punjab found 95% of water

contamination in hand or motor pumps. 19 On the other hand, public tap and tanker water samples from public water systems did not show any contamination, which was likely due to the continuous monitoring of adequate residual chlorine levels at the distribution pump houses. An investigator from this study witnessed that there was a regular monitoring of chlorine levels during interaction with water inspectors at respective water departments. A study done by Vasanthi et al states, that improper solid waste management in urban slums was a major cause of ground water contamination and this could be a reason for poor quality of hand or motor pumps and open wells in the study area.²⁰ This study reported 34% contamination of household storage water samples of which significantly more were reported from households which favored private water systems as a primary source of drinking water. A similar study executed in urban slums of Delhi demonstrated 54% of household storage water contamination.¹³

Predominantly, slum households in the study area fetched drinking water every day for consumption. Subsequently, the study didn't find it necessary to demonstrate follow up day household storage water contamination. Whereas, Brick *et al* demonstrated 67% increase in water contamination rates throughout storage periods from days 1 to 9 in urban south India.²¹

Fewtrell *et al* states, household drinking water treatment plays a major role in prevention of further contamination (if source water is contaminated) and makes water safer for consumption. Study reported that 41.3% of households treated their drinking water either by boiling or filtration. Despite this, 26.4% of treated water samples were found to be contaminated. A study by Luby *et al* based in Karachi found similar results using multiple tube fermentation technique, overall 66% of households treated drinking water either by boiling or filtration and amongst them only 16% of treated water samples were free from coliforms.²³

Unsafe defecation (open) practice is one of the major causes for diarrhoeal morbidity and mortality in children. In this study children with unsafe defecation practice were associated with 2.2 time's higher potential of having reported diarrhoea relative to children who practiced safe defecation. Studies in other developing countries like Nigeria have also reported similar findings.²⁴

This study found that children belonging to low SES had higher rates of reported diarrhea. Similar findings were observed by Gupta *et al* in a study "epidemiology of diarrhoea in urban slums". Diarrhoea in children affected both rich and poor in a society; however a strong association existed between poverty, unhygienic conditions and severity of diarrhea. ²⁶

This study observed less reported diarrhoea burden with increase in age of child. A study by Gupta *et al* in slums of West Bengal stated similar findings of decrease in diarrhoeal illness by increase in age of under-five children.²⁷ Factors such as weaning stage of breast milk feeding during this period, and introduction of inadequate nutrition may relate to higher rates of illness in children, which was out of the scope of this study.^{26,28} Water contamination rates and reported diarrhoea burden in different seasons were not measured in the study and odds of under reporting diarrhoea burden due to poor parental recall ability can be considered as limitations of the study.²⁹

CONCLUSION

This study found water samples from public taps and water tankers of public water distribution system were free of contamination and slum residents must be made aware of this and encouraged to utilize drinking water from these sources. A limited effectiveness of household water treatment process was observed in slum areas, and therefore education of effective household water

treatment is needed in this population. Also focus on behaviour change strategies would be needed to promote sanitation practices in slums.

ACKNOWLEDGEMENTS

Authors would like to acknowledge Dr. B. Devi Madhavi, Professor in Department of community medicine, Andhra Medical College. Medical officers and health workers at Primary health centres, Zone-6, Visakhapatnam

Funding: Institutional Fluid Research Grant Conflict of interest: None declared Ethical approval: Study was approved by the institutional

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Cite this article as: Veesa KS, Dimmala CS, Antipas OJH, Mohan VR, John SM. Drinking water practices and sanitation in slums of Visakhapatnam, Andhra Pradesh a developing smart city in India. Int J Community Med Public Health 2016;3:3188-94.