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Impact of Source of Drinking Water and Maternal Literacy on The Incidence and Severity of Rotavirus Diarrhea in A Developing Country Setting

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Abstract:
Aim*: To study the impact of source of drinking water and maternal literacy on the incidence and severity of symptoms of rotavirus diarrhea.*
Method*: The study is a reanalysis of data of two non-interventional prospective observational studies in children admitted with acute diarrhea at two regional hospitals - one in a rural and other in a suburban environment of West Bengal, India.*
Results: *Similar clinical manifestations of rotavirus infection were found in both localities i.e. diarrhea less than 6 days, fever, vomiting. Pain abdomen and rice watery stools were often present. Stool occult blood, WBC and ova parasite cyst were usually negative. The cases with dehydration, duration of diarrhea > 6 days, stool frequency ≥ 10 times, average stool volume ≥ 100ml and duration of hospital stay were found to be quite higher (p values: 0.000, 0.012, 0.000, 0.126, 0.000 respectively) in the rural environment. The maternal literacy was found to be higher (65% vs. 52%) in the suburban environment and there was significant difference (p value: 0.000) in the source of drinking water too.*
Conclusion: *Source of drinking water and maternal literacy directly control/effect the incidence and severity of rotavirus infection.*
Keywords: *rotavirus, maternal literacy, drinking water, diarrhea*

I. Introduction

Rotavirus gastroenteritis is the cause of 100 million cases requiring home care, 25 million clinic visits, 2 million hospitalizations, and around 0.5 million deaths in children less than 5 years of age annually (1). 82% of these deaths occur in developing countries (1). Rotavirus gastroenteritis is known to be more severe in terms of fever, vomiting and dehydration compared to non-rotavirus viral gastroenteritis (2, 3) and characteristically affects children between 6 to 23 months of age. There is thus a need to understand the factors that predict the frequency and severity of rotavirus disease in children.

There is anecdotal evidence to suggest that there is a difference in the hospital presentation of acute gastroenteritis in rural and suburban settings in India. A study of these differences could identify factors that influence severity of disease in the Indian setting. Here, we attempted to find out differences in the clinical features and the severity of symptoms present in these two groups of patients. We have also studied differences in social, economic and environmental factors in these two populations. There is contradictory evidence on the role of maternal literacy and source of drinking water on the outcome of rotavirus diarrhea (4, 5, 6, 7). Thus, we wished to explore the impact of source of drinking water and maternal literacy on the incidence and severity of symptoms of rotavirus gastroenteritis.

II. Materials and methods

We have studied infants and young children presenting with acute gastroenteritis in two environments, one in a rural environment and the other in a suburban environment of West Bengal, India. The first study group consisted of infants between the ages of 3 months and 1 year, who were admitted for management of acute diarrhea at Bankura Sammilani Medical College, Bankura, West Bengal, India between November 2002 and September 2003. This is a referral centre located in a rural environment. The other study group consisted of young children less than 2 years of age admitted at Bhatpara State General Hospital, 24 Parganas North, West Bengal, India between January 2005 and December 2007. This hospital is located in a suburban environment.

A rural area in India is characterised by a population of less than 5,000 with a density of population less than 400 per sq km and more than 25 % of the male working population is engaged in agricultural pursuits while a suburban sector is located just at the outskirts of an urban area. Infants who were not admitted in the hospital, or those who resided more than 50 km away from the hospitals, were lost on follow up. Written or

verbal consent was provided by the parents at the start of the study. The study was approved by the Ethics committee.

Acute diarrhea was defined as an episode of at least 3 loose or watery stools with or without vomiting within a 24 hour period. The study team collected clinical and anthropometric data including assessment of dehydration according to WHO guidelines (8), and detailed dietary and socio-economic history. Data collected included stool frequency which meant the average number of bowel movements per day and average stool volume that meant the average volume of each bowel movement. Decreased urination was defined as urine output less than 400 ml per day. Stool samples were collected for microscopic examination such as white blood cells, red blood cells, ova, parasite and cyst. Saline, iodine and methylene blue preparation of the specimen were examined for parasite. Bacterial culture was done on MacConkey's agar, Salmonella Shigella agar and Thiosulphate citrate bile salt sucrose agar, directly and after enrichment in alkaline peptone and selenite 'F' respectively. Thereafter the bacteria were identified as per protocol (9).

Electrophenotyping for Rotavirus from stool samples was done per Herring et al (10). dsRNA was extracted by "phenol chloroform" from a 10% suspension of stool sample in phosphate buffered saline. The dsRNA was run with Laemmli discontinuous buffer system in 10% polyacrylamide gel and silver stained by method described by Herring et al.

An assessment of the severity of the following symptoms were made: stool frequency, average stool volume, duration of diarrhea, oliguria and dehydration. We analyzed the number of cases with duration of diarrhea > 6 days, average stool volume ≥ 100 ml, stool frequency ≥ 10 times per day, oliguria, dehydration and the duration of hospital stay. All subjects remained admitted till recovery. No dietary modification was done at discharge except routine weaning advice in infants more than 4 months of age. The patients were followed up in 3 months. If the patient had active diarrhea during follow up, stool samples were tested for rotavirus.

The percentage literacy was evaluated among both fathers and mothers in both populations. The ability to read and/or write in their native language was considered as literate. The socio-economic status of the families was also evaluated. Below poverty level income was defined as family monthly income below Rs 500 (US$ 12). The families were questioned about their source of drinking water. The Pearson Chi Square test was used to test for associations between variables.

III. Results

The total number of cases of acute diarrhea in Bankura was 44 and in Bhatpara was 106. Out of these cases, rotavirus diarrhea was confirmed in 23 (68%) and 34 (29%) cases respectively (p value: 0.020) **(Table 1).**

Table 1: Locality & Rotavirus Cross tabulation

		Rotavirus		Total
		Positive	Negative	
Locality	Bhatpara	34	72	106
	Bankura	23	21	44
Total		57	93	150

Pearson Chi-Square value: 5.384, Statistical significance: 0.020*

On analysis of the clinical manifestations **(Table 2)** of rotavirus cases, it was found that along with diarrhea, 12 (52%) and 18 (53%) of cases in Bankura and Bhatpara respectively had fever (p value: 0.955), while 17 (74%) and 17 (50%) of the same had vomiting (p value: 0.071). 4 (12%) of the children in Bhatpara and none in Bankura had respiratory symptoms (p value: 0.088). The colour of stool was yellow in most cases, 48% and 54% in Bankura and Bhatpara respectively. 43% and 18% of children in Bankura and Bhatpara respectively had rice watery cholera like stools (p value: 0.033). 17% and 41% of subjects in Bankura and Bhatpara complained of pain abdomen (p value: 0.058). Occult blood in stool was found in 9% in each of Bankura and Bhatpara (p value: 0.959), while stool WBC was found in 13% and 32% of cases respectively (p value: 0.097). 4% of cases in Bankura and 15% in Bhatpara had ova, parasite or cysts in stool (p value: 0.211).

Table 2: Comparison of Clinical manifestations

	BANKURA (rural) n=23	**BHATPARA (suburban) n=34**	**Pearson Chi-square value**	**Statistical Significance (p value)**
Fever	12 (52%)	18 (53%)	0.003	0.955
Vomiting	17 (74%)	17 (50%)	3.259	0.071
Respiratory symptoms	0	4 (12%)	2.910	0.088
Rice watery stool	10 (43%)	6 (18%)	4.534	0.033*
Pain abdomen	4 (17%)	14 (41%)	3.592	0.058
Stool occult blood	2 (9%)	3 (9%)	0.003	0.959
Stool WBC	3 (13%)	11 (32%)	2.761	0.097
Stool OPC	1 (4%)	5 (15%)	1.563	0.211

*statistically significant

Table 3: Severity of Symptoms

	BANKURA (rural) n=23	**BHATPARA (suburban) n=34**	**Pearson Chi-square value**	**Statistical Significance (p value)**
Duration of diarrhea > 6 days	4 (17%)	0	6.359	0.012*
Stool frequency ≥ 10 times	13 (57%)	2 (6%)	18.143	0.000*
Average stool volume ≥ 100 ml	9 (39%)	7 (21%)	2.336	0.126
Decreased urination	8 (35%)	4 (12%)	4.373	0.037*

*statistically significant

On comparison of the severity of the symptoms in these two groups some differences were found. 17% of the children in Bankura had diarrhea for more than 6 days, while none of the 34 children in Bhatpara had so (p value: 0.012) **(Table 3)**. Stool frequency greater than or equal to 10 times was found in 57% cases in Bankura and only 6% cases in Bhatpara. Average stool volume greater than or equal to 100 ml was found in 39% cases in Bankura and 21% cases in Bhatpara. Decrease in urination occurred in 35% patients in Bankura and 12% of them in Bhatpara (p value: 0.037) **(Table 3)**. The percentages of some dehydration in patients were 52% children in Bankura and 18% children in Bhatpara while the percentages of severe dehydration were 22% children in Bankura and none in Bhatpara. (p value: 0.000) **(Table 4)**. On comparing the duration of hospital stay, majority of children in Bankura were admitted for 4 – 5 days, while majority of children in Bhatpara were admitted for 1-2 days (p value: 0.000) **(Table 5)**.

Table 4 : Assessment of Dehydration

		No	Some	Severe	Total
Locality	Bhatpara	28	6	0	34
	Bankura	6	12	5	23
Total		34	18	5	57

Pearson Chi-Square value: 19.852, Statistical Significance: 0.000*

Table 5: Duration of hospital stay in days

		1	2	3	4	5	6	Total
Locality	Bhatpara	20	8	2	2	2	0	34
	Bankura	0	0	2	7	12	2	23
Total		20	8	4	9	14	2	57

Pearson Chi-Square: 39.260, Statistical Significance: 0.000*

The percentages of literate fathers of the sick children were 70% and 65% in Bankura and Bhatpara respectively (p value: 0.703), while the percentages of literate mothers were 52% and 65% respectively (p value: 0.344). 39% of families in Bankura and 56% of the ones in Bhatpara were below poverty level (p value: 0.215) **(Table 6).** The source of drinking water for most i.e. 97% patients in Bhatpara was tap water, while of the families in Bankura, 52% used tube well, 21% used tap water, 17% used well water and 4% used pond water. The difference in the source of drinking water was statistically significant (p value: 0.000) **(Table 7)**.

Table 6: Literacy and Economic status

	BANKURA (rural) n=23	**BHATPARA (suburban) n=34**	**Pearson Chi-square value**	**Statistical Significance (p value)**
Father literacy	16 (70%)	22 (65%)	0.146	0.703
Mother literacy	12 (52%)	22 (65%)	0.895	0.344
Income below poverty level	9 (39%)	19 (56%)	1.540	0.215

Table 7: Source of drinking water

		Well	Tubewell	Pond	Tap	Others	Total
Locality	Bhatpara	0	1	0	33	0	34
	Bankura	4	12	1	5	1	23
Total		4	13	1	38	1	57

Pearson Chi-Square Value: 35.125, Statistical Significance: 0.000*

IV. Discussion

We have described in this paper a number of differences between the presentation, clinical features and environmental factors that were associated with a significantly higher incidence of rotavirus gastroenteritis in rural, in comparison to suburban settings in India. We found that the statistically significant higher incidence of rotavirus as a cause of acute diarrhea in the rural setting, in comparison to the suburban, was associated with differences in the source of drinking water in the two areas. There was statistically significant difference in the source of drinking water in the two populations, with the majority of families in Bhatpara using tap water and the majority of families in Bankura using tube well water, in addition to well, tap and pond water. Rotavirus is transmitted by the fecal-oral route and contaminated drinking water is an important source of infection (11). Well and pond water, which are open stagnant sources of water have obvious risks of contamination from infected human feces. It seems that tube well water, which is believed to be safe, was also getting contaminated in this setting. There might also be a problem beyond the point of collection, possibly with water storage. Lower literacy especially maternal literacy i.e. 52% in the rural setting, compared to 65% in the suburban setting, although not statistically significant, could play a role. All these factors may contribute to the high incidence and transmission of rotavirus in this environment. Our finding was contradictory to the results of the study by Abdollah et al in Egypt where no significant association between maternal literacy, sanitation, source of drinking water and occurrence of Rotavirus diarrhea were found (6).

Severe symptoms of rotavirus infection was observed to be significantly higher in the rural setting (Bankura) compared to the suburban setting (Bhatpara). There was statistically significant differences in cases with duration of diarrhea >6 days, stool frequency ≥ 10 times, decreased urination and dehydration. Maternal literacy and source of drinking water could also contribute to this. Education and awareness is very important among the parents to reduce the severity and the incidence of complications in diarrhea like dehydration in rotavirus diarrhea. Parents need to be educated about the importance of uncontaminated drinking water and primary home management in diarrheal diseases, especially the importance of initiating oral rehydration solution. Although availability of WHO Oral Rehydration Solution (ORS) is free of cost as a part of a national program all over the state of West Bengal, the use of it is not equal in all parts of West Bengal. It is possible that the lack of health education and low maternal literacy in the rural setting could contribute to a lower awareness of the availability of ORS and the method of use of this solution.

There is a need to study the extent of knowledge regarding decontamination and safe storage of drinking water in the two communities. Boiling drinking water fully for 1 minute will inactivate rotavirus. Using a water filter will not remove the virus as its size is very small (12). Also chlorination of drinking water for a time of 0.25 minute at a chlorine concentration of 0.20 mg/l will inactivate 99.99% rotavirus (13). After decontamination, the water must be stored in a covered, narrow mouthed, clean container. The well, pond and ground water also needs to be checked periodically by the local health authorities to ensure their safety.

The clinical spectrum of rotavirus diarrhea includes diarrhea of less than 6 days duration, fever and vomiting. There was no statistically significant difference in cases with fever and vomiting among the two populations we have studied. The high percentage of cases with fever (52% in rural and 53% in suburban) and vomiting (74% in rural and 50% in suburban) in our study was similar to findings in other studies where diarrhea, fever and vomiting have been found to be the significant manifestations of rotavirus infection. The study of 168 children below 15 years of age with acute gastroenteritis who attended the Department of Pediatrics of the University Hospital of Uppsala in Sweden showed presence of fever and vomiting in 83.9% and 86.9% cases respectively (14). The study of 295 patients in South Africa showed presence of fever and vomiting in 95.3% and 77.3% cases respectively (15). Respiratory symptoms were present in 33.33% of the children in Uppsala, Sweden. The presence of respiratory symptoms was quite low in our study (0 in rural and 12% in suburban). Pain in the abdomen was fairly common (17% in rural and 41% in suburban). The stool often resembled that in cholera i.e. rice watery, although this finding was more common in the rural environment (43%), rather than suburban (18%). It secondarily indicated the severity of diarrhea. This important finding in our study has not been stressed in studies from other parts of the world (6, 14, 15).

V. Conclusion

From our study we come to a conclusion that source of drinking water and maternal literacy may represent important variables that could play a role in the incidence, transmission and severity of rotavirus infection. With education and awareness, it may be possible to reduce the incidence of such infectious diseases even in populations that are socio-economically compromised. Safety of drinking water should be ensured and maintained at all levels starting from source to storage to consumption. We have also shown that the clinical manifestations of rotavirus infection are similar in the rural and suburban settings in India, and do not differ from that reported previously, typically including diarrhea less than 6 days, fever, vomiting, occasional abdominal pain and respiratory symptoms and a high propensity to lead to severe dehydration. We report for the first time that the diarrhea may on occasion resemble the rice watery diarrhea of cholera.

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