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Article

Socio-demographic determinants and risk factors associated with bacterial gastroenteritis in children in Bangladesh

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Abstract: Gastroenteritis is a disorder of gastrointestinal tract with symptoms of mainly diarrhea, vomiting and abdominal cramps, which is major cause of child morbidity and mortality, caused by mostly viruses, and bacteria, protozoa, etc. *E. coli* O157, *Salmonella* spp. and *Shigella* spp. play a significant role along with different sociodemographic and epidemiologic risk factors to cause bacterial gastroenteritis (BGE) in children. This study aimed to assess the burden of gasteroenteritis caused by the mentioned three bacteria, and contribution of several risk factors causing the disease in children. Stool specimens from hospitalized children were obtained along with sociodemographic and epidemiologic data. Bacterial pathogens from stools were recovered by using selective media, biochemical and serological tests. We found 15% (17/116) of the clinically suspected gastroenteritis children were infected with *Salmonella* spp. (29%), *Shigella* spp. (59%) and *E. coli* O157 (12%). A chi-square test of all (116) data revealed that sex ($p<0.05$), dehydration ($p=0.05$), contact with the diarrheal patient ($p<0.05$), past episode of diarrheal illness ($p<0.05$) and vomiting ($p<0.02$), feeding practices like only breastfeeding ($p<0.05$), breastfeeding with subsequent feeding ($p<0.05$), subsequent feeding ($p<0.05$), weaning status ($p<0.001$), family diet ($p<0.05$), types of drinking water ($p<0.002$), Father's education ($p<0.05$), occupation ($p=0.05$), and family income ($p<0.001$) were significantly associated with BGE. Determination of these potential risk factors will help to minimize the possibility of getting BGE and to reduce morbidity and mortality and also will aid to effective disease management and prevention of BGE outbreak in future.

Keywords: gastroenteritis; risk factors; socio-demographic determinants; *E. coli* O157; *Shigella* spp.; *Salmonella* spp.

1. Introduction

Gastroenteritis is inflammation ("-itis") of the gastrointestinal tract that involves both the stomach ("gastro"-) and the small intestine ("entero"-). Some common symptoms of gastroenteritis are diarrhea, vomiting, and abdominal pain and cramping (Singh and Fleurat, 2010). Globally gastroenteritis caused 477293 (8%) deaths of children under 5 years in 2016, according to the World Health Organization (WHO). In Bangladesh, the mortality of under 5 years of age children as a result of acute gastroenteritis reduced drastically from 38877 in 2000 to 7062 in 2016 (WHO, 2016). A wide range of bacteria, viruses, and protozoa causes acute gastroenteritis. In developing countries, most bacterial gastroenteritis are caused by *Vibrio* spp., enterotoxigenic *E. coli, Salmonella* spp. and *Shigella* spp. but species of *Aeromonas*, *Yersinia*, *Staphylococcus, Clostridium*, *Bacillus*, *Listeria*, etc. are hardly observed (Chow *et al*., 2010; O'Ryan *et al*., 2014).

Being the most common cause of bacterial gastroenteritis, shigellosis is endemic throughout the world. *Shigella* is responsible for 165 million cases annually of which 163 million cases are in developing countries and 1.5

million are in industrialized ones, and in developing countries, 69% of all cases are children under the age of 5 years (Chompook *et al*., 2005). In Bangladesh enterotoxigenic *E. coli* infection is most frequent followed by shigellae and rotaviruses (Black *et al*., 1982). Nontyphoidal *Salmonella* causes 94 million cases of gastroenteritis and responsible for about 155,000 deaths worldwide (Majowicz *et al*., 2010).

Different risk factors such as unsafe water supplies, poor sanitation, and nutritional deficiencies are mainly contributed to causing diarrheal diseases in developing and poor countries (Peletz *et al*., 2011). Washing hands after defecation and cleaning up child's feces is a effective practice to reduce the spread of all kinds of pathogenic microorganisms (Huttly *et al*., 1997; Clasen *et al*., 2006). Handwashing with soap can reduce 42–47% of diarrheal disease (Curtis and Cairncross, 2003). Unsafe drinking water is a vital root of diarrheal disease and child morbidity in low-income countries. The quality of sanitation facilities can reduce the spread of diarrheal illness effectively second only to hand washing.

Common housefly is a well known carrier of enteropathogens (Echeverria *et al*., 1983; Cirillo, 2006). In the majority of cases of enteric bacterial infection, bacteria are transmitted by the ingestion of contaminated food, where some potential risk factors influence infection (Walker and Black, 2010). During the first six months of infants life, only breastfeeding can decrease the probability for consumption of enteropathogens from contaminated water, food, formula, and bottles. Exclusive breastfeeding is a crucial child survival remedy during the first 6 months of life. Breastfeeding also protect children throughout the first 2 years from diarrhea specific morbidity and mortality (Lamberti *et al.*, 2011). The immunological features of breast milk shield the infant from infection, chiefly diarrhea (WHO, 2005).

According to some reports about socio-economic factors as risk factors for diarrhea, poor status or poor living conditions (Kunii *et al.* 2002; Vaahtera *et al.*, 2000) and parents low level of education were connected with escalating diarrheal diseases. Male gender, younger age, marital status, low level of education, a high number of siblings, and large households are associated with an increased incidence of diarrheal diseases. Children under-1-year-old, early weaned and from lower-income families are more susceptible to diarrhea which leads them to weight loss and stunted growth (Kunii *et al*., 2002). Children suffering from frequent diarrhea are vulnerable to malnutrition which in turn puts them at increased risk of acquiring infectious gastroenteritis and is involved with stunting and impaired cognitive development (Walker *et al*., 2012).

To generate data based on evidence, and a better understanding of bacterial gastroenteritis (BGE) caused by three major pathogens, especially *E. coli* 0157, *Salmonella* spp. and *Shigella* spp., we have conducted the study to determine socio-demographic determinants and associated risk factors of BGE.

2. Materials and Methods

2.1. Patient selection

The patients of under five years of age, with signs and sympotms of acute gastroenteritis including diarrhea, nausea, vomiting, and abdominal cramps and admitted in the different hospitals of Chattogram were selected for this study.

2.2. Data collection

A comprehensive questionnaire was designed to obtain the participant's demographic and epidemiologic data. Participant's information including sex, age, family income, number of family members, parent's education and occupations; presenting complications of fever, headache, vomiting, dehydration, duration of diarrhea, blood with stool; previous episode of diarrhea and vomiting; contact other diarrheal patients; feeding practices, time of weaning, feeding family diet, sources of drinking-domestic water, personal hygiene; practices of preserving food, immunization data, etc. have been recorded.

2.3. Specimen collection

Stool samples were collected in sterile plastic vials. Then immediately collected specimens were transported to the laboratory at the Department of Microbiology, University of Chittagong by using an insulated sample carrier at 4℃ for further analysis.

2.4. Isolation and identification of bacteria

Stool samples were inoculated in Luria-Bertani broth (Himedia, India) for 24 hours at 37˚C for enrichment. Then enriched broth cultures were aseptically inoculated onto Salmonella-Shigella agar (Himedia, India) and Hektoen enteric agar (Himedia, India) plates, and incubated at 37˚C for 24 hours. After incubation period characteristic green or blue-green, moist and raised colonies were primarily considered as *Shigella* spp. and green or blue-green colonies along with or without black center were presumptively identified as *Salmonella* spp. onto the Hektoen agar plates. Onto Salmonella-Shigella agar plates, distinct colorless colonies were initialy considered as *Salmonella* or *Shigella* species. Then standard biochemical tests including indole, methyl red/Voges-Proskauer (MR/VP), Simmon's citrate, triple sugar iron (TSI) and motility tests were conducted for the confirmation of *Salmonella* or *Shigella* species.

To isolate *E. coli* O157, stools were inoculated in modified tryptone soya broth containing novobiocin (Lab M, UK) for selective enrichment of bacteria. After inoculation specimens were incubated at 37◦C for 24 hours. Then cefixime-tellurite sorbitol MacConkey agar (CT-SMAC) (Lab M, UK) plates were streaked with the enriched culture and incubated for 24 hours at 37◦C. After incubation period, characteristics colorless colonies onto CT- SMAC agar were initially selected as *E. coli* O157 (Zadik *et al*., 1993). Then colorless colonies from CT-SMAC were subjected to slide agglutination with the *E. coli* O157 Latex test kit (Oxoid, UK) for the confirmation of *E. coli* O157.

2.5. Statistical analysis

For statistical analysis of the data, a bivariate table was constructed and a Chi-square test has been performed to find out the significance of the association between bacterial gastroenteritis and different risk factors. All the tests have been done at a 5% level of significance by using SPSS v25 and Microsoft Excel 10 software.

2.6. Ethical consideration

We have taken written permission from the institution's ethical boards to conduct the study, and written consent has been taken from the patient's attended guardian with informing aims and objectives, merits and demerits of participation in the study.

3. Results and Discussion

We obtained 116 watery stool specimens (single specimen from each child) from children under 5 years of age, clinically suspected as gastroenteritis admitted in the hospital, and found 15% (17/116) of the clinically suspected gastroenteritis children were infected with either one of the three targeted bacteria, *Salmonella* sp. (29%), *Shigella* spp. (59%) and *E. coli* O157 (12%). Demographic-epidemiological data of 116 children were analyzed to find out the association of risk factors with BGE. A bivariate table was constructed and a Chi-square test has been performed at the 5% level of significance (Table 1).

In our study, 15% of clinical gastroenteritis cases were caused by the three major bacterial agents which found concordant with the finding of Web and Starr, they showed bacteria are the cause in about 15% of gastroenteritis, with the most common types being *E. coli*, *Salmonella*, *Shigella*, and *Campylobacter* species (Webb and Starr, 2005). North America, Japan and parts of Europe, most outbreaks are due to Enterohemorrhagic *E. coli* serotype O157: H7, whereas other serotypes are important health concerns in other developed countries. *E. coli* O157 and Shiga toxin-producing *E. coli* were hardly found in Bangladesh (Islam *et*

al., 2007). In our study also, we found BGE positive cases by *E. coli* O157 is relatively lower (2%, 2/116) than the other two agents.

We found a significant association with the sex ($p<0.05$) and BGE cases, 13% of male and 14% of female children were confirmed positive with BGE, though there was no significant ($p>0.05$) association found between age and BGE. Dehydration had a significant association with BGE ($p=0.05$) where 93% (108/116) of children had dehydration, among them 13% (14/108) of were positive with BGE; 7% (8/116) children didn't report with dehydration and 38% (3/8) of them found positive with BGE. Past contact with the diarrheal patient significantly ($p<0.05$) associated with BGE where 29% (34/116) had contact with a diarrheal patient, among them 15% (5/34) found positive with BGE. Past episodes of diarrhea ($p<0.05$) and vomiting ($p<0.002$) also significantly associated with BGE. One-fourth portion of children had the past-diarrheal illness, and 17% of them found positive with BGE, where 12% of children without a previous episode of diarrhea found positive with BGE. Moreover, 24% (27/114) of the children had the previous occurrence of vomiting, among whom 7% found positive with BGE but 15% found positive with BGE among children didn't have a past occurrence of vomiting. There was a significant association of BGE with a history of feeding where 21% (24/114) of all children taken only breastfeeding ($p<0.05$), and 17% of them found positive with BGE. On the contrary, children who took breastfeeding with subsequent feed (70%, $p<0.05$) found 11% positive with BGE. In cases of children who took only subsequent feeding (11%, $p<0.05$) found 23% positive with BGE. We saw 12% (14/114, $p<0.001$) of the children who were at weaning found 21% positive with BGE. The children who have taken a family diet (68%, 77/114) were found 13% positive with BGE and deemed significantly associated ($p<0.05$). Drinking water showed a significant association ($p<0.002$) with BGE. Children taken boiled water (37/116), showed positive (8%) with BGE, municipal water was taken by 11% of the children, among them, 30% found positive with BGE. Tube-well water was taken by 9% (10/116), and 10% of them became positive with BGE. Washing hand before eating and after using the toilet didn't have a significant association with BGE as most of the children washed hand before eating (77%) and after using the toilet (91%) in this study. Father's education ($p<0.05$), occupation ($p=0.05$) and family income ($p<0.001$) were significantly associated with BGE. We found 71% (82/116) of children came from a family with moderate-income where 11% of them found positive with BGE; 28% (32/116) of the children came from a family with low-income, and BGE cases found relatively higher (19%) among them. Although the frequency of clinical gastroenteritis cases was minimum in children from a family without-income (2/116), 100% of them found positive with BGE. The preventive measures to reduce gastroenteritis including handwashing with soap, drinking clean water, proper disposal of human waste, rotavirus vaccine for children, enough fluids for mild or moderate cases, in those who are breastfed, continued breastfeeding is recommended (Ciccarelli *et al.*, 2013). A study by Majowicz *et al*. showed that 93,757,000 cases of gastroenteritis due to nontyphoidal *Salmonella* (NTS) occur annually, where NTS causes 155,000 deaths each year worldwide. By applying the average of published values of the proportion of *Salmonella* infections that is foodborne (86%), they estimated that, of the 93,757,000 cases, 80,318,000 are foodborne (Majowicz *et al*., 2010). In Bangladesh, a study of Leung *et al*. explored that 47% (219) of all NTS cases were in children < 5 years of age. NTS patients were more likely to have a higher family income (> 5,000 Taka/month), own a luxury cot, and have fewer family members sharing a drinking water source. NTS patients had significantly fewer numbers of family members using the same water source, there were no differences in the type of home construction, distance to the water source, or type of water source (Leung *et al*., 2013). In this study, there was no significant association of BGE with presenting complaints like fever, duration of diarrhea, blood with stool, types of food or food taken outside of home last week of getting gastroenteritis, food preservation practices, number of family members, and immunization etc.

Table 1. Association of different risk factors with gastroenteritis caused by *E. coli* O157, *Salmonella* spp. and *Shigella* spp.

Risk Factors			Non-bacterial gastroenteritis cases	Lab confirmed bacterial gastroenteritis cases							P-value
				Total	*Shigella* spp.		*Salmonella* spp.		*E. coli* O157		
					N	%	N	%	N	%	
	Sex	Male	87	13	8	8	4	4	1	1	0.004
		Female	12	2	1	7.1	0	0	1	7.1	
	Age	1 Year	65	12	7	9.1	3	3.9	2	2.6	0.643
		2 years	29	2	2	6.5	0	0	0	0	
		3 years	4	1	0	0	1	20	0	0	
		4 years	1	0	0	0	0	0	0	0	
Presenting Complaint	Dehydration	Yes	94	14	9	8.3	4	3.7	1	0.9	0.050
		No	5	3	1	12.5	1	12.5	1	12.5	
Presumptive source	Having contact with diarrheal patient	Yes	29	5	3	8.8	2	5.9	0	0	0.007
		No	67	9	6	7.9	1	1.3	2	2.6	
		Don't Know	3	1	0	0	1	25	0	0	
		None	0	2	1	50	1	50	0	0	
Past history of illness	Diarrheal	Yes	24	5	3	10.3	1	3.4	1	3.4	0.011
		No	75	10	6	7.1	3	3.5	1	1.2	
	Vomiting	Yes	25	2	1	3.7	1	3.7	0	0	0.009
		No	74	13	8	9.2	3	3.4	2	2.3	
History of feeding	Only Breast feeding	Yes	20	4	4	16.7	0	0	0	0	0.003
		No	79	11	5	5.6	4	4.4	2	2.2	
	Breast feeding+ subsequent feed (bottled/mixed)	Yes	71	9	5	6.3	2	2.5	2	2.5	0.006
		No	28	6	4	11.8	2	5.9	0	0	
	Only subsequent feeding	Yes	10	3	1	7.7	2	15.4	0	0	0.002
		No	89	12	8	7.9	2	2	2	2	
	Present weaning status	Yes	11	3	0	0	3	21.4	0	0	0.0001
		No	88	12	9	9	1	1	2	2	
	Feeding family diet	Yes	67	10	5	6.5	3	3.9	2	2.6	0.008
		No	32	5	4	10.8	1	2.7	0	0	
History of water consumption	Drinking Water	Boiled	34	3	2	5.4	1	2.7	0	0	0.003
		Municipal Water	9	4	1	7.7	1	7.7	2	15.4	
		Boiled and Municipal Water	17	6	6	26.1	0	0	0	0	
		Tube well	9	1	0	0	1	10	0	0	
		None	30	3	1	3	2	6.1	0	0	
	Domestic water	Tube well	60	4	2	3.1	2	3.1	0	0	0.107
		Municipal	36	11	7	14.9	2	4.3	2	4.3	
		Tube well and Municipal	1	0	0	0	0	0	0	0	
		None	2	2	1	25	1	25	0	0	

History of personal hygiene	Washing hand before eating	Usually	77	12	7	7.9	3	3.4	2	2.2	0.352
		Sometimes	20	3	2	8.7	1	3.4	0	0	
		Never	2	2	1	25	1	25	0	0	
	Washing hand after toilet	Usually	90	15	9	8.6	4	3.8	2	1.9	0.521
		Sometimes	6	0	0	0	0	0	0	0	
		Never	3	2	1	20	1	20	0	0	
Family status	Fathers Education	Illiterate	11	2	1	7.7	1	7.7	0	0	0.041
		Primary	16	4	0	0	2	10	2	10	
		Secondary	44	7	7	13.7	0	0	0	0	
		Higher Secondary	28	4	2	6.3	2	6.3	0	0	
	Mother's Education	Illiterate	6	3	1	11.1	1	11.1	1	11.1	0.263
		Primary	14	0	0	0	0	0	0	0	
		Secondary	56	8	5	7.8	3	4.7	0	0	
		Higher Secondary	23	6	4	13.8	1	3.4	1	3.4	
	Father's occupation	Worker	30	6	2	5.6	3	8.3	1	2.8	0.053
		Job Holder	39	5	3	6.8	1	2.3	1	2.3	
		Business	25	3	3	10.7	0	0	0	0	
		Service Holder	5	1	1	16.7	0	0	0	0	
		None	0	2	1	50	1	50.0	0	0	
	Family income	Moderate	73	9	8	9.8	1	1.2	0	0	0.0001
		Low	26	6	1	3.1	3	9.4	2	6.3	
		None	0	2	1	50	1	50	0	0	

4. Conclusions

Although this study had some potential limitations, and the sample size was not adequate to represent the full scenario of bacterial gastroenteritis in children under 5 years of age in the region, it generated some significant evidence-based data on the some important risk factors of the three major pathogens like *E. coli* O157, *Salmonella* spp. and *Shigella* spp. causing gastroenteritis in the children. The determination of potential risk factors of bacterial gastroenteritis will help the community to fight against the diseases, and will eventually contribute to improving public health.

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Conflict of interest

None to declare.

Author's contribution

Mohammad Sharif Uddin contributed to lab analysis, collection of data, writing the manuscript including the literature review. Imam Hossain and Sutapa Bhowmik wrote sections of the manuscript, analyzed the data, and provided overall supervision of the study. All authors read and approved the final manuscript.

References

Black RE, KH Brown, S Becker, AA Alim and MH Merson, 1982. Contamination of weaning foods and transmission of enterotoxigenic Escherichia coli diarrhoea in children in rural Bangladesh. Trans. R. Soc. Trop. Med. Hyg., 76: 259-264.

Chompook P, S Samosornsuk, L Von Seidlein, S Jitsanguansuk, N Sirima, S Sudjai and H Lee, 2005. Estimating the burden of shigellosis in Thailand: 36-month population-based surveillance study. Bull. World Health Organ., 83: 739-746.

Chow CM, AK Leung and KL Hon, 2010. Acute gastroenteritis: from guidelines to real life. Clin. Exp. Gastroenterol., 3: 97-112.

Ciccarelli S, I Stolfi and G Caramia, 2013. Management strategies in the treatment of neonatal and pediatric gastroenteritis. Infect. Drug. Resist., 6: 133-161.

Cirillo VJ, 2006. "Winged sponges": houseflies as carriers of typhoid fever in 19th and early 20th-century military camps. Perspect. Biol. Med., 49: 52-63.

Clasen T, I Roberts, T Rabie,W Schmidt and S Cairncross, 2006. Interventions to improve water quality for preventing diarrhea. Cochrane Database Syst. Rev., 3: CD004794

Curtis V and S Cairncross, 2003. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. Lancet Infect. Dis., 3: 275-281.

Echeverria P, BA Harrison, C Tirapat and A McFarland, 1983. Flies as a source of enteric pathogens in a rural village in Thailand. Appl. Environ. Microbiol., 46: 32-36

Huttly SR, SS Morris and V Pisani, 1997. Prevention of diarrhoea in young children in developing countries. Bull. World Health Organ., 75: 163-174

Islam MA, AK Heuvelink, E De Boer, PD Sturm, RR Beumer, MH Zwietering and KA Talukder, 2007. Shiga toxin-producing *Escherichia coli* isolated from patients with diarrhoea in Bangladesh. J. Med. Microbial., 56: 380-385.

Kunii O, S Nakamura, R Abdur and S Wakai, 2002. The impact on health and risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. Public Health, 116: 68-74.

Lamberti LM, CL Fischer Walker, A Noiman, C Victora and RE Black, 2011. Breastfeeding and the risk for diarrhea morbidity and mortality. BMC Public Health, 11: 1-12.

Leung DT, SK Das, MA Malek, D Ahmed, F Khanam, F Qadri and ET Ryan, 2013. Non-typhoidal *Salmonella* gastroenteritis at a diarrheal hospital in Dhaka, Bangladesh, 1996–2011. Am. J. Trop. Med. Hyg., 88: 661-669.

Majowicz SE, J Musto, E Scallan, FJ Angulo, M Kirk, SJ O'Brien, TF Jones, A Fazil, RM Hoekstra and International Collaboration on Enteric Disease "Burden of Illness" Studies, 2010. The global burden of nontyphoidal *Salmonella* gastroenteritis. Clin. Infect. Dis., 50: 882-889.

O'Ryan GM, L Ashkenazi-Hoffnung, MA O'Ryan-Soriano and S Ashkenazi, 2014. Management of acute infectious diarrhea for children living in resource-limited settings. Expert Rev. Anti Infect. Ther., 12: 621-632.

Peletz R, M Simuyandi, K Sarenje, K Baisley, P Kelly, S Filteau and T Clasen, 2011. Drinking water quality, feeding practices, and diarrhea among children under 2 years of HIV-positive mothers in peri-urban Zambia. Am. J. Trop. Med. Hyg., 85: 318-326.

Singh A and M Fleurat, 2010. Pediatric Emergency Medicine Practice Acute Gastroenteritis. Pediatr. Emerg. Med. Pract., 7: 1-20

Vaahtera M, T Kulmala, K Maleta,T Cullinan, ML Salin and P Ashorn, 2000. Epidemiology and predictors of infant morbidity in rural Malawi. Paediatr. Perinat. Epidemiol., 14: 363-371.

Walker CF and RE Black, 2010. Diarrhoea morbidity and mortality in older children, adolescents, and adults. Epidemiol. Infect., 138: 1215-1226.

Walker CLF, L Lamberti, L Adair, RL Guerrant, AG Lescano, R Martorell, RC Pinkerton and RE Black, 2012. Does Childhood Diarrhea Influence Cognition Beyond the Diarrhea-Stunting Pathway? PLoS ONE, 7: e47908.

Webb A and M Starr, 2005. Acute gastroenteritis in children. Aust. Fam. Physician, 34: 227.

WHO, 1995. Meeting on the Potential Role of New Cholera Vaccines in the Prevention and Control of Cholera Outbreaks during Acute Emergencies, 2005. Document CDR/GPV/95.1. World Health Organization, Geneva, Switzerland Organ.

WHO, 2016. Global Health Observatory (GHO) data 2016: causes of child mortality. Available: http://www.who.int/gho/child_health/mortality/causes/en/.