BRAC University Journal, Vol. IV No. 1, 2007, pp. 103-109

WATER QUALITY TESTS AND BEHAVIORAL FACTORS OF CHILD DIARRHOEA IN DHAKA SLUMS

Mohammad Jahangir Alam
Economics and Social Science
BRAC University
66 Mohakhali, Dhaka-1212, Bangladesh
E-mail: jahangir@bracuniversity.ac.bd

ABSTRACT

Diarrhoeal disease is one of the leading causes of morbidity and mortality in less developed countries, especially among children aged 0-5 years. It is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water. Diarrhoea prevalence rate for the children in Dhaka slums is 214.29. The total costs of children's diarrhoea (adding all the direct and indirect) in Dhaka slums is Tk. 133.88 over a 15 day time interval. The water quality is measured at the point-of-use and the point-of-source by the total coliform, faecal coliform, and faecal streptococci tests per 100 ml water. The total coliform, faecal coliform, and faecal streptococci are at the point-of-source 651, 450, and 71 and at the point-of-use 919, 636, and 80 respectively. The test values at the point-of-use are greater than that at the point-of-source due to drinking water contaminated by behavioral activities. Due to the almost perfect correlation between the total coliform, faecal coliform, faecal streptococci tests, we need to drop the values from these two tests (total coliform and faecal streptococci) in the econometric analysis. We will use the faecal coliform test, as it is the test most commonly referred to in the existing literature.

Key words: Diarrhoea, slum, coliform, water, behavioral activities, and correlation

I. INTRODUCTION

Diarrhoeal disease is one of the leading causes of morbidity and mortality in less developed countries, especially among children aged 0-5 years (Fewtrell et. al 2005). Global estimates of the numbers of deaths due to diarrhoea have shown a steady decline, from 4.6 million in the 1980s (Snyder and Merson 1982) to 3.3 million in the 1990s (Bern et al. 1992) to 2.5 million in the year 2000 (Kosek, Bern, and Guerrent 2003). However, diarrhoeal diseases continue to be an important cause of morbidity and mortality worldwide, and despite all advances in health technology, improved management, and increased use of oral rehydration therapy (ORT) in the past decades, they remain among the five major killers of children under five years of age. In contrast to mortality trends, morbidity due to diarrhoea has not shown a parallel decline, and global estimates remain between two and three episodes of diarrhoea per child under five per year. Kosek, Bern, and Guerrent (2003) estimates a global median incidence of diarrhoea to be 3.2 episodes per child-year in the year 2000, similar to those found in the previous reviews by Snyder and Merson (1982) and by Bern et al. (1992) as well as to those reported in the first edition of Disease Control Priorities in Developing Countries (Jamison et al. 1993). Yet every child in Bangladesh suffers an average of three to five diarrhoeal attacks in each year, which is a major contributor to malnutrition. According to the statistical survey, around 125,000 children under five die each year from diarrhoeal disease; that is, 342 children per day (IPRSP 2002).

Table-1: Distribution of known Death Due to Disease in Dhaka Slum

Disease	Percentage
Diarrhoea	27
Tetanus	22
Respiratory Problem	12
Measles	11
TB	2
Fever	16
Accidents	10

Source: Hussain, 1999

Dhaka, one of the primary urban centers of Bangladesh, has been experiencing a rapid increase in population over the past two decades. People migrate to Dhaka and most migrants work in marginal employment at very low wages and live in squatter and slum settlements with few basic services. Recent studies estimate that 2 million people live in the urban slums of Dhaka. This problem is only expected to worsen—by 2020, the number of people living in urban slums in Dhaka is expected to rise to 9 million. Table-1 shows that diarrhoea is the leading known cause of death of children less than 5 years old in Dhaka slum areas.

The main purpose of the study is to calculate the household economic cost due to child diarrhoea in Dhaka slum, to examine the water quality test for child diarrhoea, and to predict the behavioral factors for prevalence of child diarrhoea. With these objectives, the paper has been organized as follows: The next section discusses the literature review. Section III discusses the profile of the sample households. Section IV presents the diarrhoea prevalence in Dhaka slums. Section V presents the household cost of child diarrhoea. Section VI describes the drinking water quality in Dhaka slums VII explains the behavioral factors in child diarrhoea. Section VIII explains the correlation between the water quality tests. The paper is concluded in the section IX.

II. LITERATURE REVIEW

Diarrhoeal disease is usually attributed to ingestion of water or foods that are contaminated with fecal coliforms or other pathogens, or to fecal-oral contamination. For pathogens transmitted by the faecal–oral route, drinking-water is only one vehicle of transmission. Contamination of food, hands, utensils and clothing can also play a role, particularly when domestic sanitation and hygiene are poor. Improvements in the quality and availability of water, in excreta disposal and in general hygiene are all important in reducing faecal–oral disease transmission. The expanding water connection and sanitation are not sufficient condition to improve child health status. The source of ambiguity lies in the uncertainty about how access to water interacts with private health inputs such as hygiene water storage, boiling water, medical treatment and nutrition (Jalan and Ravallion 2003). Same source of ambiguity arises about the hygiene of sanitation. With right combination of water and sanitation facilities with behavioral characteristics of household, diarrhoeal disease is almost preventable.

We can use two terms (economic/behavioral and engineering/infrastructure) for identifying factors linked with the incidence and severity of diarrhoeal illness (Alberini et al. 1996). The engineering/ infrastructure perspective emphasizes the need to provide households with a plentiful and reliable supply of uncontaminated water and adequate sanitation services. The engineering/infrastructure variables (like piped water) are more important for reducing diarrhoea and the knowledge of hygiene promotes more effective water use for reducing diarrhoea (Jalan and Ravallion 2003). Parents are always willing to pay for improving water quality (Whittington et al. 1992; and Jalan and Ravallion 2003) for their children's well-being. Parents are more willing to pay for protecting their male child compared with their female child suffering from a diarrhoeal episode (Amin and Khondaker 2004). Dhaka slums households also are willing to pay for a public water connection or common tap for shared use (Chowdhury 1999).

The economic/behavior perspective emphasizes attention to and interpretation of household behavior, and the relationship between the appropriate interventions and the resources and preferences of the households. The lack of awareness among mothers about hygiene (like use of soap, ash or soil for hand washing by mother and children after defecation and before having main meals) leads to exposure of children to diarrhoea (Han and Hliang 1989; Knight et al. 1992; Hoque et al. 1999; and Jalan et al. 2003). These factors are often tightly intertwined. One might find, for instance, that diarrhoea incidence is low in a city with contaminated water, because households are careful in their personal hygiene, and boil water before drinking (Alberini et al. 1996). In such a setting, an engineering intervention, such as improvement in water quality, could less effective in lowering diarrhoea than the behavioral factors.

III. PROFILE OF SAMPLE HOUSEHOLDS

The study sites are limited to slums located in the Dhaka Metropolitan Area (DMA). A total of 40 households in 10 slums were interviewed in a recall period of 15 days. The households were selected on the basis of drinking water source and sanitation type, as specified by LGRD office. The criterion

for household selection was that each household must have at least two child aged between 0-5 years. 17.5% of the respondents were male and 82.5% of the respondents were female.

The minimum number of children below age of 5 in the households interviewed was 2, since this was the criteria for household selection. Households had on average 5.82 members, with the mean age of respondents 29.28 years and the mean age of the household head is 35.83 years. Average monthly household income is Tk.5915.25. Due some extreme values which is measured by the standard deviation in the income data, mode income (Tk. 3600) would be good measure for measuring the central value of the income in slums.

Table-2: Profile of the Sample Households

Variable	Obs	Mean	Std. Dev.	Min	Max
Children (0 to 5 years)	40	2.10	.30	2	3
Household member	40	5.82	1.92	4	12
Age of respondent (Years)	40	29.28	8.60	20	60
Age of household head (Years)	40	35.83	9.76	22	60
Household monthly income (Tk.) (Exchange Rate: 1$=69Tk)	40	5915.25	4563.19	2010	22500
	40	Median income		4500	
	40	Mode income		3600	

Source: Field Survey, 2006

IV. DIARRHOEA PREVALENCE IN DHAKA SLUMS

Prevalence rate for the entire sample is 90.13. For children, the prevalence rate is 214.29 and when we consider male and female children separately, the prevalence rate is 186.05 and 243.90 respectively (Table 6). This shows that children are more susceptible to diarrhoea than adults and female children are more likely to suffer from diarrhoea than male children, perhaps suggesting parental negligence towards daughters. Diarrhoea for female children is higher than for male due to females being more prone to eating stale food and not seeking medical treatment.

Table-3: Diarrhoea Prevalence Rates of the Sample Households

Definition	*Prevalence Rate/1000*
1. For entire sample (number of cases/ total number of population)	90.13
2. For children (number of cases/ total number of children)	214.29
3. Male children (total reported cases of male children diarrhoea/total number of male children)	186.05
4. Female child (total reported cases of female children diarrhoea/total number of female children)	243.90

Source: Field Survey, 2006
Definition of prevalence rate (PR) = (total number of cases/ total population surveyed) * 1000

V. HOUSEHOLD COSTS OF CHILD DIARRHOEA

The direct costs of diarrhoea includes the home treatment, transportation cost, doctor's fees, and medical expenses and the indirect cost includes the parent's work and leisure lost due to child diarrhoea. We converted leisure time costs of child diarrhoea into monetary terms by multiplying the time lost by a proportion of the hourly wage of an individual in the household. For this study, we considered 50% of the average hourly wage rate (mean hourly wage rate was 3.59 Tk.). The 50% estimate is similar to fractions used in estimating time costs of water collection in Nepal (Pattanayak et al. 2005).

Table-4: Direct and Indirect Costs of Child Diarrhoea (Tk.) (15 days)

Costs of Diarrhoea	Obs	Mean	Std. Dev.	Min	Max
Home treatment	2	30	28.28	10	50
Transportation	1	20	-	20	20
Doctor's fee	3	40	26.46	10	60
Medical expenses	14	66.29	79.92	5	275
Direct cost of child diarrhoea	**14**	**80.57**	**101.10**	**5**	**355**
Parent's work lost due to child diarrhoea	11	58.79	42.79	10.78	143.7
Parent's leisure lost due to child diarrhoea	13	17.96	16.20	3.59	64.66
Indirect cost of child diarrhoea	**13**	**67.70**	**59.21**	**3.59**	**208.36**
Total cost due to child diarrhoea	**15**	**133.88**	**117.94**	**8.59**	**455.59**

Source: Field Survey, 2006

The cost of home treatment for the children's diarrhoea for 15 days is on average Tk. 30. The transportation costs related to children's diarrhoea for 15 days is Tk.20, the doctor's fees are on average Tk.40 and the costs of medication are on average Tk.66.29. the opportunity cost of parents work and leisure hours lost due to children's diarrhoea are on average Tk.58.79 and Tk.17.96 respectively. The direct and indirect costs of child diarrhoea are on average Tk. 80.57 and Tk. 67.70 respectively. The total cost of children's diarrhoea for a single household is calculated by adding all these variables and over a 15 day time interval, the mean of total costs of children's diarrhoea is Tk. 133.88 in Dhaka slums.

VI. DRINKING WATER QUALITY IN DHAKA SLUMS

The questionnaires were serially numbered according to the sequence in which the households were interviewed. Four households were interviewed from each slum and water sample was collected from every "third household" at the end of the interview. We collected 10 water samples from the point-of-use and 10 water samples from the point-of-source. Bottles were opened only at the time of collecting the water sample, either from the source or point of use. Water samples were sent to the laboratory within three hours of collection.

Table-5: The Mean Value of the Water Quality Test

Water Quality Test	Point-of-Source	Point-of-Use
Total Coliform per 100 ml water	651	919
Faecal Coliform per 100 ml water	450	636
Faecal Streptococci per 100 ml water	71	80

Source: Field Survey, 2006

The total coliform, faecal coliform, and faecal streptococci test values are reported as colony forming units (cfu) per 100 ml water. The total coliform, faecal coliform, and faecal streptococci are at the point-of-source 651, 450, and 71 and at the point-of-use 919, 636, and 80 respectively. The test values at the point-of-use are greater than that at the point-of-source due to drinking water contaminated by behavioral activities.

The possibility of variation between the water quality at source and point of use is due to day-to-day variations in tap water quality. Storing water collected the previous day is a common practice among slum-dwellers. Therefore, there is a possibility that the water sample collected from the household being interviewed was actually collected the previous day, but the water sample collected from the source is on the day of the interview. In this case, the variations in water quality between

source and point of use would be partially due to differences in quality of supple water and it would be incorrect to conclude that the entire variation is due to behavioral activities.

VII BEHAVIORAL FACTORS IN CHILD DIARRHOEA

Household members spend time walking to and waiting at the point-of-source. We converted time costs of water collection into monetary terms by multiplying the time spent by a proportion of the hourly wage of an individual in the household. For this study, we considered 50% of the average hourly wage rate since women mostly collects water and they are usually housewives. The 50% estimate is similar to fractions used in estimating time costs of water collection in Nepal (Pattanayak 2005). For a period of 15 days, water collection costs from safer source is Tk.13.17. the water treatment costs are Tk.22.97 and the cost of containers used for carrying water from the source and storing the water in the house comes to an average of Tk.1.77 and Tk.0.3 respectively. The cost of lid is on average Tk.0.26 for a 15 day period (Table 5). Among 40 households only 6 households are treating their drinking water and 26 households are using lid their storing container.

Table-6: Water-related Costs (Tk.) (15 days)

Variable	Obs	Mean	Std. Dev.	Min	Max
Collection	40	13.17	22.65	.47	105
Treatment	6	22.97	25.94	.1	60
Carrying container	40	1.77	1.77	.3	8.54
Storing container	40	.3	3.96	1.38	.84
Lid cost	26	.26	.25	.04	.83

Source: Field Survey, 2006

The total coliform, faecal coliform, and faecal streptococci test values are higher in the point-of-use than in the point-of-source because of their storing system and collection of water from the container and the point-of-source are not hygienic.

VIII. CORRELATION BETWEEN THE WATER QUALITY TESTS

The correlation between the total coliform and the faecal coliform in the point-of-source is 0.983 (almost perfect correlation) and the correlation between the total coliform and the faecal coliform in the point-of-use is 1.00 (perfect correlation).

Table-7: Correlations between the Water Tests. (Significance Level in Parentheses)

Water Test		Source			Use		
		A	**B**	**C**	**D**	**E**	**F**
Source	Total Coliform [A]	1	.983** (.000)	.966** (.000)	.170 (.639)	.169 (.641)	.201 (.579)
	Faecal Coliform [B]	.983** (.000)	1	.976** (.000)	.023 (.949)	.023 (.949)	.050 (.891)
	Faecal Streptococci [C]	.966** (.000)	.976** (.000)	1	.070 (.848)	.070 (.848)	.148 (.683)
Use	Total Coliform [D]	.170 (.639)	.023 (.949)	.070 (.848)	1	1.000** (.000)	.961** (.000)
	Faecal Coliform [E]	.169 (.641)	.023 (.949)	.070 (.848)	1.000** (.848)	1	.959** (.000)
	Faecal Streptococci [F]	.201 (.579)	.050 (.891)	.148 (.683)	.961** (.000)	.959** (.000)	1

Source: Field Survey, 2006
** Correlation is significant at the 0.01 level (2-tailed).

The correlation between the total coliform and the faecal streptococci in the point-of-source is 0.966 (almost perfect correlation) and the correlation between the total coliform and the faecal streptococci in the point-of-use is 0.961 (almost perfect correlation). The correlation between the faecal coliform and the streptococci in the point-of-source is 0.976 (almost perfect correlation) and the correlation between the faecal coliform and the streptococci in the point-of-use is 0.959 (almost perfect correlation).

Due to the almost perfect correlation between the total coliform, faecal coliform, faecal streptococci tests, we need to drop the values from these two tests (total coliform and faecal streptococci) in the econometric analysis. We will use the faecal coliform test, as it is the test most commonly referred to in the existing literature (Purnamita 2005 and Alberini et al. 1996).

IX. CONCLUSION

Diarrhoeal disease is one of the leading causes of morbidity and mortality in less developed countries, especially among children aged 0-5 years. It is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water. Diarrhoea prevalence rate for the children in Dhaka slums is 214.29, and when considered separately, are 186.05 and 243.90 for male and female children respectively. The direct and indirect costs of child diarrhoea over 15 days are on average Tk. 80.57 and Tk. 67.70. The total cost of children's diarrhoea for a single household is calculated by adding all the direct and indirect costs and over a 15 day time interval. The mean of total costs of children's diarrhoea in Dhaka slums is Tk. 133.88. The water quality is measured at the point-of-use and the point-of-source by the total coliform, faecal coliform, and faecal Streptococci tests per 100 ml water. The total coliform, faecal coliform, and faecal Streptococci are at the point-of-source 651, 450, and 71 and at the point-of-use 919, 636, and 80 respectively. The test values at the point-of-use are greater than that at the point-of-source due to drinking water contaminated by behavioral activities. Due to high fuel costs, slum dwellers do not treat their drinking water. Due to the almost perfect correlation between the total coliform, faecal coliform, faecal streptococci tests, we need to drop the values from these two tests (total coliform and faecal streptococci) in the econometric analysis. We will use the faecal coliform test, as it is the test most commonly referred to in the existing literature.

ACKNOWLEDGEMENTS

I gratefully acknowledge the financial support provided by the South Asian Network for Development and Environmental Economics (SANDEE).

REFERENCES

1. Alberini, Anna, et al. "Determinants of Diarrhoeal Disease in Jakarta." Policy Research Working Paper, 1568. The World Bank, Policy Research Department, Public Economics Division. January 1996.
2. Amin, M. and Farhana Khondaker. "A contingent valuation study to estimate the parental willingness to pay for childhood diarrhoea and gender bias among rural households in India." Health Research Policy and Systems. 2.3, 2004.
3. Bern, C., J. Martines, I. de Zoysa, and R. I. Glass. 1992. "The Magnitude of the Global Problem of Diarrhoeal Disease: A Ten-Year Update." Bulletin of the World Health Organization *70: 705-14*
4. Chowdhury, N.T. (1999), 'Willingness to pay for water in Dhaka slums: A Contingent Valuation Study', edited by Ahmad et al., IUCN-The World Conservation Union, Association of Green Accounting, *Environmental Economics in Bangladesh,* 105-116.
5. Fewtrell, Lorna, et al. "Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: A Systematic Review and Meta-Analysis" Lancet Infect Dis. 5 (2005):42-52.
6. Freeman, A. Myrick, III. The Measurement of Environmental and Resource Values: Theory and Methods. 2nd ed. New York: Resource for the Future, Washington, DC, 2003.
7. Gunatileke, Herath M. Environmental Valuation: Theory and Applications. Sri Lanka: Postgraduate Institute of Agriculture, University of Peradeniya, 2003.

8. Jalan, Jyotsna and Martin Ravallion. "Does Piped Water Reduce Diarrhoea for Children in Rural India?" Journal of Econometrics. 112 (2003): 153-173.

9. Jalan, J., Somanathan E., Chowdhury S. (2003), 'Awareness and the demand for environmental quality: drinking water in urban India', *South Asian Network for Development and Environmental Economics (SANDEE)*, Working paper series, No.4-03.

10. Jamison, D. T., H. W. Mosley, A. R. Measham, and J. L. Bobadilla. 1993. Disease Control Priorities in Developing Countries. New York: Oxford University Press.

11. Han, A. and Hlaing T (1989), 'Prevention of diarrhoea and dysentery by hand washing', *Trans R Soc Trop Med Hygiene*, 83; 128-131.

12. Harrington, W., and P.R. Portney (1987), 'Valuing the Benefits of Health and Safety Regulation', *Journal of Urban Economics*, 22 (1): 101-12

13. Hussain, Akhtar, et al. "Determinants of Mortality among Children in the Urban Slums of Dhaka City, Bangladesh." Tropical Medicine and International Health. 4.2 (1999): 758-764.

14. Kosek, M., C. Bern, and R. Guerrant. 2003. " The Global Burden of Diarrheal Disease, As Estimated from Studies Published Between 1992 and 2000". Bulletin of the World Health Organization, 81: 197-204.

15. Liu, J., Hammitt J., Wang J., and Liu J.L. (2000), 'Mother's willingness to pay for her and her child's health: a contingent valuation study in Taiwan', *Health Economics*, 9: 319-326.

16. Pattanayak, Subhrendu K., et al. "Coping with Unreliable Public Water Supplies: Averting Expenditures by Households in Kathmandu, Nepal." Water Resources Research. 41, W02012, doi: 10.1029/2003WR002443 (2005).

17. Poverty Reduction Strategy Paper (December, 2002), 'A National Strategy for Economic Growth, Poverty Reduction and Social Development (PRSP)', *Economic Relations Division, Ministry of Finance*, Bangladesh.

18. Shyamsunder, P. (2002), 'Poverty-environment indicators', *Environmental Economic Series*, The World Bank, Paper No.84.

19. Snyder, J. D., and M. H. Merson. 1982. "The Magnitude of the Global Problem of Acute Diarrheal Disease: A Review of Active Surveillance Data". Bulletin of the World Health Organization, 60: 605-13.

20. The World Bank (2002), 'The Environment and the Millennium Development Goals', Hurtado *et al*.

21. Viscusi, W.P., Magat W., and Huber J. (1987), 'An investigation of the rationality of consumer valuations of multiple health risks', *Rand Journal of Economics*, 18:456-479.

22. Whittington D., Briscoe J., and Mu X. (1987), 'Paying for urban services: A study of water vending and willingness to pay for water in Onitsha, Nigeria', The World Bank, Washington D.C, *World Bank Paper,* INU 40.

23. Whittington, D., Altaf M. A., and Haroon J. (1992), 'Willingness to pay for water in rural Punjab, Pakistan', UNDP/World Bank, Washington D.C., *Water and sanitation program*.

24. World Health Organization (2002), 'The World Health Report 2002', *WHO*, Geneva, Switzerland.