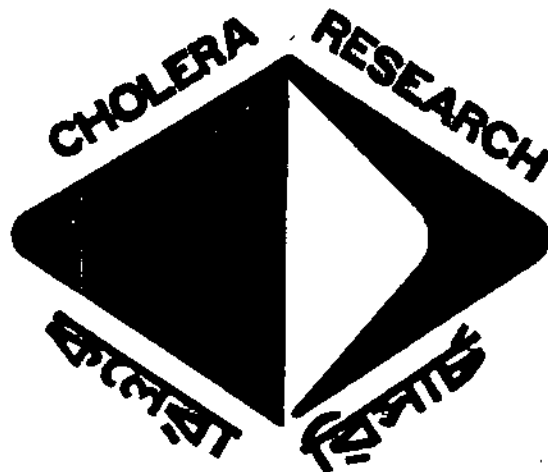


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THE INFLUENCE OF DRINKING TUBEWELL
WATER ON DIARRHEA RATES IN
MATLAB THANA, BANGLADESH

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RATES IN MATLAB THANA, BANGLADESH

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PREFACE

The Cholera Research Laboratory (CRL) operates under a bilateral project agreement between the government of Bangladesh and the United States of America. Research activities center on the inter-relationships between diarrheal disease, nutrition, fertility and their environmental determinants. These series of working papers, demonstrating the type of research activity currently in progress at CRL, are preliminary reports issued to stimulate discussion and criticism. The views expressed in these papers are those of authors and do not necessarily represent views of the Cholera Research Laboratory. They should not be quoted without the permission of the authors.

In 1974 the Cholera Research Laboratory began a program to study the environmental determinants of risk of acquiring infectious diarrheal disease. An initial major effort was the prospective two-year study of the impact of handpump tubewells on diarrhea rates in 12 villages in Matlab Bazar Thana which was undertaken with UNICEF/Dacca support. This report is a preliminary exposition of data gathered during the first year.

This paper was presented at the Twelfth Joint Conference on Cholera at the U.S.-Japan Cooperative Medical Science Program in Sapporo, Japan, October, 1976.

The authors wish to thank Mr. William Journey, formerly with the water resources division, UNICEF/Dacca for encouragement and assistance in the early phases of this study, Mr. Awal, water resources program, for his valuable technical assistance and Mr. Azizul Huq, CRL field surveillance assistant and his staff in this project.

ABSTRACT

Diarrheal disease is a major health problem in Bangladesh, especially among the younger age groups. Although recent clinical advances have remarkably reduced the mortality of treated cases, prevention, which is acknowledged to be the ultimate means with which to control morbidity and mortality of diarrhea, remains largely ineffective in traditional rural societies such as Bangladesh.

One effort to reduce infectious diarrheal disease incidence underway in Bangladesh is the rural tubewell water improvement program. Recently, UNICEF and the Bangladesh government announced a plan to double the number of available tubewells in the rural areas. This paper gives the first year results of a UNICEF-CRL study of the impact handpump tubewells have on the health as measured by diarrhea rates in a rural population in Matlab.

During the first year, weekly household surveillance for diarrhea among approximately 20,000 persons in 12 villages revealed striking patterns of seasonal and age-specific rates. As expected, younger ages had higher rates but the observed reduction in overall rates of 50% during the monsoon was not expected. Approximately 40% of the residents drank tubewell water although insignificant numbers used tubewell water for other domestic purposes. Drinking tubewell water was not associated with a reduction in overall diarrhea rates or in the hospitalized or outpatient rates of cholera or shigellosis.

A complete analysis will follow the collection of the second year's data. The preliminary conclusion appears to be that tubewells, as they are currently used, are not associated with a reduction in diarrhea rates.

INTRODUCTION

Cholera transmission has been associated with water since the early days of John Snow and this assumption is widely held today. Many recent studies in the cholera endemic area of Bangladesh have confirmed the association, but the details of the role of water in the mode of transmission of cholera have not been clearly outlined.

Attempts to control cholera through improved methods of treatment and immunoprophylaxis are worthy short-term goals; but the eventual control of enteric diseases such as cholera is assumed to lie in the direction of improved hygiene which would reduce the risks of infection. It is apparent to visitors to a cholera endemic area that this approach is a long-term proposition.

A corollary to the "law" of waterborne transmission of cholera states that the provision of safe water supplies would reduce the transmission of cholera. A companion corollary states that safe sewage disposal, which should reduce contamination of the environment, would also lead to diminished transmission of cholera. The majority of people living in cholera endemic areas in Bangladesh are very poor and reside in rural areas. It is a challenge to modern technology and

rural development to improve the standard of hygiene in areas in which the most widely applied technological advances such as piped water and sewage disposal systems cannot be used.

Matlab Bazar Thana in Bangladesh is flooded four months of the year. In this area, the hydrology is very complex and most water tables tapped by shallow handpump tubewells are unpalatable due to the high iron content which exceeds 10 parts per million in some areas. Conversely, the surface water is of much better quality in many respects. For instance, the canal water near the rural health centre at Matlab has a lower mineral concentration than single-distilled tubewell water as measured by electrical conductivity. Furthermore, surface water is warm and pleasant to bathe in, does not make ladies' hair difficult to manage, does not discolor cooked rice and is much more readily accessible to the average family in our field study area.

Efforts to approach the problem of improving rural standards of hygiene have been underway for many years and one device, the handpump tubewell, has been recommended for decades. In Bangladesh, international agencies and the government have launched a massive program to double the number of such wells in the rural areas. The stated purpose of this \$40 million

program is to control cholera and other waterborne diarrheal diseases by increasing the availability of tubewells. We feel it is unwise to assume that mere provision of safe drinking water sources would necessarily reduce waterborne illness rates if people were exposed to contaminated sources of water for other uses.

UNICEF asked the Cholera Research Laboratory (CRL) to evaluate the impact of existing tubewells on enteric disease rates to better understand the effect of the present tubewell program and how current programs could be improved. The CRL undertook to study the impact of the handpump tubewell on cholera, shigellosis and overall diarrheal illness rates in 12 villages in our field study area. This is a report of the first year's observations of this study.

METHODOLOGY

Villages in the CRL field surveillance area were canvassed with respect to numbers of functioning handpump tubewells. Villages were ranked on the basis of people per tubewell and stratified with respect to distance from readily available surface water. Twelve villages were selected to represent a range of combinations of access to tubewell water and surface water at various times of the year. Approximately 20,000 people

reside in these villages. Beginning in January, 1975 field workers visited each family weekly to ask each individual about diarrhea occurring at the time of the visit and diarrhea episodes since his last visit. Workers recorded overnight absences from home and the number of days a person had diarrhea (defined as two or more watery stools or soft stools with blood or mucus per day). Persons absent for more than 50% of the days of the month were excluded from the analysis for the month. An episode was defined as having diarrhea for at least one day following a minimum of two days of normal stool.

During the first year, cultures were not taken in the field and the following data from field surveillance regard episodes of diarrhea without an etiological diagnosis. In addition, basic data regarding the source of water for domestic use was recorded on one day in the month when the individual was asked specifically about the source of water he used the previous day for drinking, bathing, cooking, washing utensils and using after toilet. A systematic 5% sample throughout the study area was made on alternate months to check the validity of the response with respect to use of tubewell water by measuring the electrical conductivity of the water in each container in the house.

In addition to episodes of diarrhea detected in the weekly household morbidity survey, confirmed cases of cholera and shigellosis detected among participants at the Matlab hospital were analyzed with respect to their drinking water histories recorded during the field survey. Therefore, in addition to overall diarrhea rates, this report gives the impact of drinking tubewell water on the rates of cholera and shigellosis based on confirmed cases of these two enteric infections diagnosed at our hospital.

To ensure a constant availability of tubewell water, a mechanic was assigned to make periodic checks and repairs of existing tubewells.

RESULTS

Every tubewell in the study area produced water with higher electrical conductivity values than any available surface water, and a measure of conductivity clearly delineated tubewell and surface water. A systematic survey of 5% of 3,500 families failed to detect a single case of misreporting tubewell water for drinking purposes. We assumed a household with at least one container of tubewell water did, in fact, represent a family whose members drank tubewell water; and a family with no container of tubewell water in the house was

assumed to be a non-tubewell water-drinking family.

As expected, the age-specific diarrhea rates show a striking preponderance of disease in the younger age groups. As Table 1 illustrates, the rates in the 0-4 year age group males and females combined, were approximately 3 to 4 times that of the 10-14 or 15+ age groups which were the lowest. The rates for the 5-9 year age groups were intermediate. Although there was considerable inter-village variation in the proportion of the population drinking tubewell water, within each village the same proportion of each age group drank tubewell water constant.

TABLE 1

AGE-SPECIFIC DIARRHEA RATES/1000 BY TWO-MONTH PERIOD							
Age	Jan- Feb	Mar- April	May- June	July- Aug	Sept- Oct	Nov- Dec	Annual
0-4	383	496	267	214	169	332	155
5-9	227	266	108	128	178	157	89
10-14	97	148	66	74	55	78	43
15+	128	149	67	66	59	93	47
All Ages	96	119	57	54	54	75	75

Therefore, there was no need to determine age-adjusted rates when comparing one village to another.

Somewhat surprisingly, tubewell use did not change drastically throughout the year. Though there are marked seasonal differences in the elevation of surface water, the proportion of the population drinking tubewell water was remarkably constant in each village as shown in Table 2. A slight trend upward in the use of tubewell water was noted at the end of the year. We did not conduct an education campaign and this may represent the minor effect of continually asking people about tubewell water and increasing their awareness of a benefit by using it. The upward trend in tubewell use was represented in all age groups.

We feel there are two reasons why one village cannot be compared directly to another village with respect to the impact of drinking tubewell water on enteric disease rates. First, there may have been inter-observer differences in diagnosing an episode of diarrhea. The field staff was instructed as to our definition of diarrhea, but we did not cross-check to see that two observers would obtain similar rates in the same village. We insisted, however, on having each field worker remain in the village in which he began to work so the definition of diarrhea for each particular village would be constant throughout the study. Field workers were to apply these same criteria for diagnosis to both tubewell water and non-tubewell water

TABLE 2

PERCENT OF PARTICIPANTS DRINKING TUBEWELL WATER
BY TWO-MONTH PERIOD

Village	Number of* Participants	Jan- Feb	Mar- April	May- June	July- Aug	Sept- Oct	Nov- Dec	Average
D82	1388	45	46	44	48	47	51	47
V36	2672	18	19	19	19	20	26	20
V88	313	87	87	87	83	83	84	85
C	2090	9	6	6	9	9	33	11
D100	2295	79	87	89	83	86	86	84
V47	1255	3	6	5	12	14	13	9
D42	1049	27	25	20	22	22	24	23
VB11	1466	89	89	91	91	91	93	91
D73	888	76	76	74	79	78	81	78
D77	714	35	36	33	40	38	37	37
D74	256	56	62	66	66	66	63	62
D76	715	0	0	0	0	0	0	0
All villages	15101	40	42	41	42	43	48	43

* Average number of residents present 50% or more of the days in each two-month period.

drinkers. Second, no one assumes that all villages share equal risks of experiencing high rates of diarrhea. The critical measurement compares diarrhea rates within each village among those who drink tubewell water and among those who do not drink tubewell water.

Table 3 compares diarrhea rates among those who drink tubewell water and those who do not drink tubewell water for each two month period in each village. Regardless of the source of drinking water, similar seasonal patterns of diarrhea were observed in each of the 12 study villages. In Matlab Bazar Thana, diarrhea rates during the high-water, monsoon period vary between one-half and one-quarter what they are in the low-water, winter season.

With regard to two specific diseases, cholera and shigellosis, and their association with drinking tubewell water, the following data were extracted from hospital records of patients from the 12 study villages. Table 4 shows the cholera rates for each two-month period during the year for those who drank tubewell water and those who did not drink tubewell water. In five of six two-month periods, cholera rates were higher among tubewell drinkers although in only two periods were the differences statistically significant. The annual

TABLE 3

DIARRHEA RATES/1000 FOR TWO-MONTH PERIOD BY DRINKING WATER SOURCE

Village	drinking sources	Jan- Feb	Mar- April	May- June	July- Aug	Sept- Oct	Nov- Dec	annual
D82	TW	129	174*	145**	91	108	121	128
	SW	158	220	100	90	104	97	130
V36	TW	89	124	96	47*	51***	101	86**
	SW	95	139	76	74	105	123	102
V88	TW	208*	215	177	167	118	154	174
	SW	366	293	146	96	204	140	201
C	TW	439	770***	179	243*	185	161	397***
	SW	212	397	157	168	173	154	214
D100	TW	297*	222**	104	118	144*	159*	176
	SW	354	290	115	115	91	108	199
V47	TW	229	390***	95	103	87	306*	192***
	SW	140	212	89	69	68	217	135
D42	TW	130***	149	95	128*	51	47	102***
	SW	58	114	74	84	46	34	69
VB11	TW	149	143	122	52	94	124	114
	SW	117	162	95	79	118	93	113
D73	TW	80**	83	15	3	1	1	31*
	SW	142	101	5	0	5	0	46
D77	TW	174	96	12	28	21	38	59
	SW	207	135	8	23	13	26	67
D74	TW	33	23	0	0	0	0	9
	SW	25	75	0	0	0	0	19
D76	TW	-	-	-	-	-	-	-
	SW	102	103	13	32	23	20	49

§ TW = tubewell; SW = surface water

* p < .05

** p < .01

*** p < .001

TABLE 4

CHOLERA RATES/1000 BY SOURCE OF DRINKING WATER
AND TWO-MONTH PERIOD

Drinking water source	Jan- Feb	Mar- April	May- June	July- Aug	Sept- Oct	Nov- Dec	Annual*
Tubewell	.315	.618	.484	.157	2.202**	.561	4.322
Other	.106	.773	.00	.00	.241	.129	1.037
			p<.05		p<.001		p<.001

* Weighted average.

** An outbreak of cholera occurred in village VB11 in which 91% of all participants drink tubewell water. In this village, there was no significant difference between drinkers and non-drinkers of tubewell water in cholera attack rates.

rates were four times higher among those who drank tubewell water although this difference was exaggerated by a large outbreak in September-October in one village in which 91% of all participants drank tubewell water. Within that village there was no difference in cholera rates during the outbreak between persons drinking tubewell water and those not drinking tubewell water. This is an example of distortion which may occur when diarrhea outbreaks appear within villages of heavy tubewell use.

Table 5 shows the shigellosis rates in each two-month period for those who drink tubewell water and those who do not drink tubewell water. The rates are lower for tubewell water drinkers but the differences are not statistically significant.

TABLE 5
SHIGELLA RATES/1000 BY SOURCE OF DRINKING WATER
AND TWO-MONTH PERIOD

Source of drinking water	Jan-Feb	Mar-April	May-June	July-Aug	Sept-Oct	Nov-Dec	Annual*
Tubewell	.0	.309	.323	0	0	.280	.926
Other	0	.217	.672	0	0	.643	1.498

* Weighted average.

DISCUSSION

It is widely accepted that providing safe drinking water will decrease the risk of acquiring waterborne enteric diseases. Cholera is assumed to be the classic waterborne diarrheal disease. Shigellosis has been termed a "water washed" disease which suggests that the quantity of water available for washing and general improvement in hygiene are more important in determining risk of infection than the quality of water. Although these distinctions may be true overall, we feel this is an oversimplification. In rural Bangladesh, where polluted surface

water is readily available and more acceptable to the population, the role of improved water sources in improving health in the community is very complex. Approximately 40% of the people in this study drink tubewell water primarily. However, less than 1% among the approximately 15,000 participants in the study used tubewell water for any purpose except drinking or trivial uses such as washing feet. Surface water is used for bathing, food preparation, utensil washing and water for ablution following defecation.

There are no clear reasons why we failed to detect a consistent pattern relating drinking tubewell water and diarrhea rates. Although drinking tubewell water may not be strongly associated with diarrhea rates, there may be a consistent relationship which is obscured by other factors. For example, persons drinking tubewell water may cluster near tubewells and episodes of diarrhea may cluster geographically around sources of transmission relatively independent of tubewell location. We know that outbreaks of diarrhea move from one location to another within the village, as well as from one village to another. If drinking tubewell water only partially protects against transmission of diarrhea, the overall rate among all tubewell water drinkers will be high compared to non-tubewell water drinkers when an outbreak is located in the part of the

village where tubewell use is high and vice versa when the outbreak moves to a part of the village where tubewell use is low. Further analysis of these data from specific sections of each village may help measure the role of tubewells in the risk of acquiring diarrhea. The same reasons which make us unwilling to compare one whole village to another, make it unjustified to compare one part of a village to another part of the same village although such a breakdown into smaller geographic units is an improvement. Ideally, one should assess the impact of tubewells in an area where the residents are subjected to the same risks of acquiring diarrhea except with regard to tubewell use. If, in examining the effect of tubewells on diarrhea rates within small epidemiologic units, no consistent pattern emerges, the case against significant impact of tubewells is greater.

These findings should not be interpreted as a blanket condemnation of the role of water improvement programs in improving the health of rural communities. However, these data indicate that there appears to be little justification for expanding the present program in Bangladesh. We would be not cautious to limit conclusions from Matlab to areas of comparable hydrology. In the Bangladesh context, surface water is an integral part of the rural culture and the small amount

of protection afforded by drinking tubewell water may be overwhelmed by the exposure to polluted surface water through bathing, food preparation and utensil washing.

One might ask the question, under these circumstances, what can be done to improve the performance of rural water improvement programs? We feel these data indicate that a great deal of work must be done to provide a measurable health benefit from tubewells. The handpump itself is unchanged since its introduction. It is designed to draw water to the surface to fill containers, and rural Bengalis use the pump precisely for this purpose. The present handpump is unsuited for many other uses such as bathing and utensil washing for which people need safe water. Therefore much of the potential benefit of the existing, limited technology has been realized, and, apparently it has little, if any, demonstrable effect on diarrhea rates.

Our data indicate that the approach to rural water improvement programs for health benefits must be modified. In our opinion, the following two changes are required at the outset. First, social engineering research must be applied to the problem of defining methods for delivery of adequate quantities of safe, potable water which will encourage people to use this water exclusively for the entire spectrum of domestic uses.

water including drinking, bathing, food preparation and utensil washing. Anthropologists and sociologists must guide the engineers in the design of a water delivery system which will completely replace surface water for uses which affect the health of the population.

Second, the attack on the eventual control of waterborne diseases cannot be left exclusively to social scientists, engineers and planners. If health benefits are a goal of water improvement programs, their impact must be measured in terms of improved health. It is unacceptable to continue to estimate the impact of such programs in terms of intermediate statistics such as increases in the availability of safe drinking water sources. Monitoring infectious diarrhea rates provides a direct measure of the health status of a community which can be influenced by water improvement programs.

In view of the relatively slow progress which has been made in years of solid biomedical research in prevention and control of cholera, we suggest that research be pursued vigorously in defining the methods and the cost effectiveness of "ultimate solutions" to the cholera problem. Many scientific presentations about control and immunoprophylaxis of infectious diarrheal diseases state that the ultimate control of cholera and other infectious enteric diseases will come only through

the eventual improvement of the standard of hygiene and the overall standard of living of populations at risk. We submit that the eventual control of cholera and other enteric diseases indeed does lie in that direction, but this goal is as distant as ever at this time. With the rapidly growing population in areas in which cholera and shigellosis are endemic, the chances of reaching this goal are decreasing as the population density increases.

The scope of the problem is immense and the need for active participation of the biomedical research community is apparent. We must bring the rigorous discipline of the scientific method through the specialized skills of epidemiology, microbiology, and the powers of clinical observation to bear on what are essentially programs to improve health.

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