IMPACT OF THE HANDPUMP TUBEWELL ON DIARRHEAL DISEASE RATES IN RURAL BANGLADESH

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Introduction

Cholera transmission has been associated with water since the early days of John Snow and this assumption is widely held in the modern age. 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.

While attempts to control cholera through methods of treatment and immunoprophylaxis are worthy short-term goals, the eventual control of enteric diseases such as cholera is assumed to lie in the direction of improved hygiene and thereby reducing the risks of infection. (It is apparent to visitors to a cholera endemic area this approach is a long-term proposition.)

A corollary to the "law" of waterborne transmission of cholera states that 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 technologica advances such as piped water and sewage disposal systems canno be used.

Matlah Bazar Thana in Bangladesh is flooded for four months of the year. In this area the hydrology is very complex and most water tables tapped by sallow handpump tubewells are unpotable 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 both a chemical and aesthetic sense. The conductivity of river water near the rural health centre at Matlab is lower than single-distilled tubewell water. 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 forty million dollar program is to control cholera and other waterborne diarrheal diseases by increasing the numbers of available tubewells. We feel it is unwise to assume 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 to evaluate the impact of existing tubewells on enteric disease rates to better understand the effect of the tubewell program and how new 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 the combinations of access to tubewell water and surface water at various times of the year. Approximately 20,000 people reside in these villages. A cadre of field workers was trained to conduct diarrhea morbidity surveillance by visiting 200 families weekly to enquire about diarrhea at the time of the visit or diarrhea since his last visit. Workers record overnight absences from home and the number of days a person had diarrhea. Both watery diarrhea and dysentery are recorded as diarrhea. Persons absent for more than 50% of the days of the month are not included in the analysis for the month. An episode of diarrhea is 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 uses 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 use 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 conductivity of the water in each container in the house. 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 drinking family.

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 this report gives the impact drinking tubewell water has on the rates of cholera and shigellosis based on confirmed cases of these two enteric infections diagnosed at our hospital as well as overall diarrhea rates.

Results

Every tubewell in the study area produced water with higher conductivity than any available surface water. Thus, a measure of conductivity clearly delineated tubewell and surface water. A systematic survey of 5% of families failed to detect a single case of misreporting tubewell water for drinking purposes.

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 intervillage variation in the proportion of the population drinking tubewell water, within each village the age-specific rates of tubewell use were relatively constant. 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, and therefore marked differences in the availability of surface water, the proportion of the population drinking tubewell water was relatively 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 therefore making them aware of the possibility of a health impact 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, inter-observer differences in defining an episode of diarrhea undoubtedly occured. The field staff were 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 to the definition for each particular village would be relatively constant throughout the study. Second, no one assumes 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 where observed in each of the twelve 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 tubwell water the following data were extracted from hospital records of patients from the twelve 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 period cholera rates were higher among tubewell drinkers although in only two periods were the differences statiscally significant. The annual 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 perons drinking tubewell water and those not drinking tubewell water. This is an example of distortion which may occur when diarrhea outbreaks appear in areas 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 tubwell water. The rates are lower for tubewell drinkers but the differences are not statistically significant.

Discussion

It is widely accepted as an article of faith that providing safe drinking water will decrease the risk of acquiring waterborne enteric diseases. Cholera is assumed to be the classic waterborne diarrheal disease, and shigellosis has been termed a "water washed" disease suggesting that the quality of the water or the fact that the infection is acquired through water is not as important in determining risk of transmission as the quantity of water available for handwashing and general improvement in hygiene. 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. However no one among the 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 answers 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, 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 quantitate the role of tubewells in the risk of acquiring diarrhea. For the same reasons we are unwilling to compare one whole village to another, we are not justified in comparing 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 there appears to be little justification for expanding the present program in Bangladesh. In the Bangladesh context surface water is an integral part of the rural culture and the small amount of protection afforded by drinking bacteriologically safe 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 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 technology has been realized, and, apparently, it has little if any demonstrable effect on diarrhea rates.

Our data indicate the approach to rural water improvement programs for health benefits must be restructed. 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 to deliver adequate quantities of safe, potable water which will encourage people to use this water exclusively for the entire spectrum of domestic uses of 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 affecct the health of the population.

Second, the attack on the eventual control of waterborne diseases cannot be left exclusively in the area of concern of social scientists, engineers and planners. 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. If health benefits are a goal of water improvement programs their impact must be measured in terms of improved health. 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 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 the ultimate control of cholera and other infectious enteric disease will come only through the eventual improvement of the standard of hygiene and the overall standard of living of populations at risk. We submit 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 observations to bear on what are essentially programs to improve health.

TABLE 1

AGE-SPECIFIC DIARRHEA RATES/1000

BY TWO-MONTH PERIOD

Age	Jan-Feb	Mar-April	May-June	July-Aug	Sept-Oct	Nov-Dec
0-4	383	496	267	214	169	332
5-9	227	266	108	128	178	157
10-14	97	148	66	74	55	78
15+	128	149	67	66	59	93

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

TABLE 3

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

Village	drinking source §	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
			$p<.05$		$p<.001$		$p<.001$

* 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.

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