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Tubewell water consumption and its determinants in a rural area of Bangladesh

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Summary

As part of the evaluation of a water supply, sanitation and hygiene education project in rural Bangladesh, the consumption of water from the improved supplies was estimated from an observational study. Women volunteers observed and recorded all water collection activities of each group of households using a handpump over a 2-day period. Data from questionnaire surveys on household characteristics were related to per capita use of water. The mean household water consumption rate was 43 l per capita per day. Univariate analyses showed that several factors were significantly associated with water consumption, including family size and age structure, occupation, distance from the house to the handpump, the number of people served by a handpump, and possession of luxury items. Multiple regression analysis showed that several factors remained associated with per capita consumption, although their predictive value was low. The method of measuring water consumption, and the policy implications of the findings, are discussed.

Introduction

One of the main objectives of the International Drinking Water Supply and Sanitation Decade (1981-1990) is the provision of an adequate, safe supply of water. The expected reduction in levels of water-related diseases due to this provision can be achieved only if the improved water supplies are functioning well and utilized by the population. Previous studies in Bangladesh have shown that the provision of tubewells resulted in most households using these supplies for their drinking water, but that the use of readily available traditional water sources for many domestic purposes remained widespread (Hughes *et al.* 1977; Khan *et al.* 1981). Few studies have been conducted, however, to assess the consumption of water. We describe here results from a survey carried out as part of the evaluation of a water supply, sanitation and hygiene education project in a rural area of Bangladesh. The consumption of water from improved supplies was measured and related to several socioeconomic and physical household attributes. This enabled us to determine some factors that are important to consider in the planning of water supply projects, even when, as was the case here, a comparatively high handpump to population ratio was implemented.

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Materials and methods

PROJECT DESCRIPTION

The Mirzapur Handpump Project is an intervention package consisting of water supply (through a newly developed handpump—the Tara pump), sanitation (through the construction of double-pit water-sealed latrines), and health and hygiene education (through project staff and the training of women volunteers in the community). Beginning in 1984 the project was implemented in two villages, composed of approximately 800 households and 4800 people, at Mirzapur. This is a rural area in the delta region of Bangladesh, and is located about 60 km north of Dhaka.

The Tara handpump is a locally manufactured non-suction low-lift pump made mostly of plastic components. It is easy to operate and to maintain, and provides good quality water in large volumes throughout the year. One hundred and forty-six Tara pumps were installed in the project area, so that together with some UNICEF pumps previously installed, the handpump to population ratio is about 1 to 30.

SURVEYS

In March 1987 (the dry season) an observational study was conducted at 138 of the Tara handpumps. Other Tara pumps were undergoing repairs and hence were excluded from the study. All UNICEF pumps were also excluded since monitoring data, necessary in the calculation of water consumption (see below), were not collected for these pumps. Prior to this study, a survey was conducted to identify every household using each pump. The collection of handpump water was recorded from 0530–2130 h over 2 consecutive days. Women from the user group of a neighbouring handpump were engaged in this data collection and, although the majority were illiterate, a simple methodology was devised such that their performance was highly satisfactory. Two women, on a rota basis, were assigned to each pump for the first day and another two for the second day. Their presence caused minimum disturbance to water collection activities and their involvement made the task of household membership identification easy. The observers were visited three times a day by project staff (approximately one to 5 or 6 pumps).

Each observer was provided with family photographs of the handpump's user group, two pots (of different colours) for each household and some stone chips. For each stroke pumped by a household member, a stone chip was put into one of that household's two pots. One pot was for full strokes (pumped by adults) and the other for half strokes (pumped by children). A multiplying factor based on the discharge rate of each pump (available from fortnightly monitoring of all Tara pumps) was used to give the household consumption of handpump water (in litres) over the two days. This figure was divided by 2 and by the number of people in the household to give an average daily per capita consumption rate (litres per capita per day, $l\ c^{-1}\ day^{-1}$).

This observational study method had been previously pilot-tested on a cluster of 12 handpumps on two occasions separated by a few days, with different observers employed on each occasion. The results obtained were similar on each occasion. Data from four of the 12 pumps were compared to results obtained from electronic water flow meters and showed good agreement for three of them. The flow meter on the fourth pump gave an unrealistically high reading, a problem which occurred frequently so that this equipment could not be relied upon for measuring water consumption. Hence the observational method was adopted for the entire area.

Monthly demographic surveillance provided data on the size and age–sex composition of each household. Adult occupation and education were known from baseline data, and a socio-economic survey conducted in August 1987 yielded information on household possessions, amounts of land and cattle owned, and the availability of certain food items—fish, eggs and milk. The distance of each household to the handpump was measured and the approximate number of persons using each pump was recorded.

Results

The handpump water collection activities of 594 households (comprising 3869 people) served by the 138 handpumps were monitored over the two-day period. Some households were absent from the area at the time of the study and a few were excluded because of uncertainty over household composition due to marital disruptions and other reasons. Figure 1 shows the distribution of the average water consumption rates. The wide range reflects the fact that households used water for different activities. For example, a household washing clothes at the handpump site on one of the observation days would have a higher water

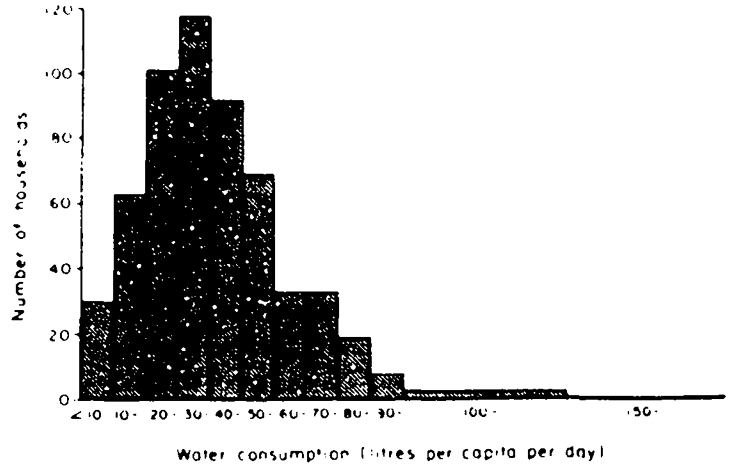

Figure 1. Histogram of tubewell water consumption per capita per day (averaged over a 2-day period) in 594 households.

consumption rate than a household just collecting for use in the home. The mean consumption rate was 43 l c^{-1} day^{-1} (95%, confidence interval for the mean = 41–45 l c^{-1} day^{-1}).

The mean water consumption rates for the factors under study are shown in Table 1. Consideration of each factor separately showed that water consumption was significantly higher

(i) for households consisting of smaller numbers of people;
(ii) where no children under 5 years were living;
(iii) where the household head was engaged in non-agricultural work;
(iv) where the handpump was located close to the house;
(v) where the size of the group using pump was less than 20 persons;
and
(vi) where the household owned at least one 'luxury' possession (radio, bicycle, watch, ceramics).

Although not statistically significant, consumption rates were also higher in households where the head had received more than 10 years education and in households of Hindu faith. No relationship was found between water consumption and education of the spouse or the highest family education, ownership of cattle or land, or use of 'luxury' food items.

Multiple regression analysis was used to determine the combined effects of the factors in Table 1. A regression model fitted to the dependent variable (y, water consumption) showed that the variance of the residuals increased with the predicted values of y. A logarithmic transformation of y solved this problem and the residuals closely followed a normal distribution. It was found that although several factors make a significant contribution to the regression model, their predictive value is rather low (multiple correlation coefficient $r^2 = 0.18$). Of the factors considered, family size, number of children under 5 years of age, distance to handpump from the house, and the possession of at least one luxury item remained significantly associated with water consumption.

Discussion

It is becoming increasingly recognized that quantity of water is as or more important than quality of water in the prevention of diarrhoeal diseases (Cairncross 1987; Huttly *et al.* in press). However, the task of accurately measuring water quantity is not simple.

Many factors influence consumption patterns and there is likely to be substantial variation from day to day, depending on particular requirements. Added to this is the difficulty in obtaining accurate data on the amount of water collected at any one time. In the early stages of the project, electronic water flow meters were used to measure the water discharged from the handpumps. These meters proved very unreliable and so an alternative approach was sought

Table 1. Water consumption and household factors

Factor (No. households)	Levels	Percentage of households	Mean water consumption ($l\ c^{-1}\ day^{-1}$) (s.e. of mean)	*P*-value of test statistic*
No. of people in household (594)	1–3	15	60 (4.6)	< 0.001
	4–6	44	41 (1.5)	
	7–9	25	41 (1.7)	
	10 +	16	34 (1.7)	
No. children < 5 years (594)	0	43	50 (2.1)	< 0.001
	1	34	38 (1.5)	
	> 1	22	36 (1.5)	
Religion (580)	Muslim	67	41 (1.3)	0.06
	Hindu	33	46 (2.1)	
Education of head (years) (594)	0	65	41 (1.4)	0.07
	1–10	31	46 (2.0)	
	> 10	3	51 (6.8)	
Occupation of head (594)	agricultural	45	39 (1.4)	0.004
	other	55	46 (1.7)	
Distance from house to handpump (m) (593)	0–24	9	56 (3.7)	< 0.001
	25–49	28	49 (2.1)	
	50–99	42	42 (1.8)	
	100 +	20	31 (1.9)	
User group size of pump (persons) (594)	< 20	15	49 (3.1)	0.06
	20 +	85	42 (1.2)	
Possession of luxury item (575)	none	48	40 (1.5)	0.026
	any	52	45 (1.6)	

*Either the *z*-test or one-way analysis of variance were performed when group variances were similar, otherwise an approximate test for difference of means (Armitage & Berry 1987) or a logarithmic transformation was used. The *P*-value refers to an overall comparison between subgroup means. Two-tailed significance tests were used.

in the form of an observational study. Where standard sized containers are used for water collection, amounts can be easily measured. It is more common to find, however, that a wide variety of containers are used and their volume must therefore be estimated or measured directly using more intrusive techniques than simple observation. Also, as was the situation here, the design of the handpumps and platforms and the high handpump to population ratio encouraged use of water at the handpump site; that is, the water did not enter a container. Whilst realizing that pump discharge rates vary with stroke length and speed, the counting of strokes pumped in two groups of half and full length, combined with the average discharge rate for each pump known from monitoring data, provided the best possible estimate of the volume of water consumed by a household.

Employment of local women, use of photographs, and the fact that only one person could obtain water from the handpump at any one time, helped to maximize the correct identification of individuals from households. It would perhaps have been more informative to differentiate between water used at the handpump site and that carried away, but this would have increased the complexity of the study method.

The methodology used in this observational study provided a simple and unobtrusive way of data collection, and whilst recognizing that some limitations in accuracy are involved we are confident that the data are of good quality. We also believe that with careful planning, this method of data collection can be replicated in other settings for similar types of observational studies.

Our results have shown that even when measurements of water consumption were made over a 2-day period, a wide range of per capita consumption was found. Several factors were related to consumption but the multiple regression analysis revealed that a large proportion of variation remained unexplained. This implies that either important factors were not measured or simply that day to day variations within each household are large, so that measurements taken over a limited period do not give a fully representative estimate of average consumption. If our observations had been conducted over several days or 1 to 2 weeks, the accuracy of our estimates would have improved. Logistical constraints, in the form of other project surveys, prevented extension of the observation period in this study. It can also be argued that considerable amounts of water from other sources may have been used. The study was conducted in the peak of the dry season, however, so that this effect should be small.

Overall, water consumption rates were high with a mean rate of 43 l c^{-1} day^{-1}. This figure may be in excess of the minimum required to allow adequate personal and domestic hygiene. Only 16% (93/594) of households used less than 20 l c^{-1} day^{-1} on the days of observation. This high consumption rate is the most important finding of the study and suggests the basic soundness of the project design in terms of pump technology, pump density and supportive education. The finding of higher consumption rates among smaller households confirms the results of other studies (Feachem *et al.* 1978; White *et al.* 1972). The number of young children also affected consumption with lower rates among households with one or more children under 5 years old. This effect was still present even when the number of people in the household was controlled for. Whilst this might seem reasonable on the one hand (young children would presumably consume less water used for drinking and cooking) it might have been expected that more water would be used for washing the child. Without information on the purposes for which the water was collected, it is difficult to draw conclusions about this finding.

Previous studies have shown that water consumption is greatest when the improved water supply is located within the homestead, relatively constant when located up to about 1 km away, and decreases thereafter (Cairncross 1987). In our situation, households were located close to the pumps (80% less than 100 m), and yet we found a decreasing trend in average consumption as the distance to the pump increased. On average, each handpump served 30 people and variations in this number appeared to have little influence on water consumption once other factors had been taken into account. Households using handpumps serving a small group of people were more likely to be located closer to the pump and this latter factor appeared a more important determinant of water consumption.

Several of the socioeconomic factors studied (occupation, education, ownership of land or cattle, and household possessions) were closely related, so that although a univariate analysis showed some of them being associated with water consumption, only the possession of a 'luxury' item made a significant contribution to the regression analysis. Exactly why households of a lower socioeconomic status use less water is not known but since this is a group at greater risk of diarrhoeal disease (Islam *et al.* 1984), our results emphasize the importance of giving special attention to this group in the health education component of the project.

In summary, this unique method of data collection has enabled us to study quantitatively a variable which water supply projects strive to increase, namely, the volume of water used per capita per day. The project was clearly successful in achieving high rates of water consumption. However, despite a high handpump to population ratio, consumption did vary widely between households according to several factors. Consideration of these factors is of importance in the planning and siting of handpumps in similar water supply projects, and in defining those households which are to be the main targets of associated health and hygiene education.