

EFFECT OF PIPED WATER SUPPLY ON HUMAN WATER CONTACT PATTERNS IN A *SCHISTOSOMA HAEMATOBIIUM*-ENDEMIC AREA IN COAST PROVINCE, KENYA

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Abstract. The effect of a piped water supply on human water contact in a *Schistosoma haematobium*-endemic area in Coast Province, Kenya was studied. After the construction of five community standpipes and one shower unit, there was a 35.1% reduction in the number of people observed using river water, a 44.1% reduction in the frequency of contact with river water, and a 25.4% reduction in the amount of contact. The frequency of river water contact per person also decreased significantly, but the amount of contact per person did not decrease. The total frequency of contact decreased significantly except for washing clothes by the river, washing utensils, and fishing. The frequency per person did not change for most of the activities and significantly increased for washing clothes. The frequency of river water contact in households with high piped water consumption showed a significant decrease compared with those with low piped water consumption. The volume of consumption of piped water was inversely proportional to the distance from the home to the community standpipe. These results indicate that in the study area, the effect of a piped water supply on river water contact behavior was heterogeneous while the total river water contact decreased significantly, and that the piped water had a beneficial effect on some villagers but very little effect on others.

Humans are responsible for the spread of schistosome infection, and the pattern of schistosome infection depends on human behavior, especially contact with infested water. Measures that reduce this contact will reduce schistosome infection. A safe water supply, used in conjunction with mass chemotherapy, is an effective measure in the control of schistosomiasis.¹ It reduces the frequency and degree of human contact with infested water and subsequently leads to a lower equilibrium level of transmission. However, the effect of a water supply on the transmission of schistosomiasis has not been fully understood. There are many reports on the impact of a safe water supply on the prevalence and/or the intensity of infection in particular communities.^{2–14} However, among them, only a few reports have examined the impact of a safe water supply on water contact behavior.^{9, 11, 12}

Since 1981, we have been conducting a schistosomiasis haematobia control program in a small village in Kenya. In the study area, a combination of mass chemotherapy and the introduction of a safe water supply was started in February 1984. Community standpipes were constructed and a shower unit was built at a primary school. The present work examines to what extent the provision of a safe water supply reduced contact with river water in the study area.

MATERIALS AND METHODS

Study area. The study area, Mwachinga village, is located in the Kwale District, Coast Province, Kenya. The land is undulating, dotted with houses on the hills, and partially cultivated. The climate may be roughly divided into four seasons: a long rainy season from April to June, a cool dry season from July to October, a short rainy season in November, and a hot dry season from December to March. The number of residents registered in the 1982 census was 1,208 (557 males and 651 females); approximately half of the population were less than 15 years of age. The overall prevalence and intensity of infection were 68.2% and 50.0 eggs

per hr (equivalent to 28.1 eggs per 10 ml of urine), respectively.¹⁵ The number of residents increased after piped water was provided and reached 1,460 (669 males and 791 females) in the 1986 census. Two rivers, the Pemba and Kadingo, flow through the village (Figure 1). The flow of the Pemba River is perennial, but some parts of the Kadingo River dry up in the dry season, leaving small pools.

Community water supply. Piped water was supplied to the study area in February 1984. Five community standpipes were constructed in the village, and a shower unit with five rooms was built at a primary school located in the center of the village (Figure 1). Showers were free of charge, but the villagers had to pay 10 Kenya cents (0.5 U.S. cents) for a bucket of water (about 20 liters) taken for household use. The community standpipes and shower units were maintained by the water committee of the village. The villagers in charge of community standpipes recorded the names of villagers who collected water and the amount of water taken from May 1984 to April 1985. Since the records at one community standpipe were not complete, we excluded the households using this community standpipe from analysis.

Water contact study. Water contact was measured by direct observation.^{16–18} The study sites were 16 major points that had been identified as busy sites by a questionnaire. The study sites were divided into two groups of eight points each, and each was observed by one local observer who could identify each villager. The water contact behavior of the villagers was recorded from 6:00 AM to 6:30 PM. The information collected was name, sex, age, type of activity, and duration of water contact. Observation of water contact was carried out on Tuesdays (normal weekdays), Fridays (holidays for Muslims), Saturdays and Sundays (weekends). Each of the 16 sites was observed for one day in each month, and on each of the four different observation days in each four-month period. Therefore, to cover the four different observations days for one site, a four-month period (i.e., a block) was necessary. Since we started the observations in June,

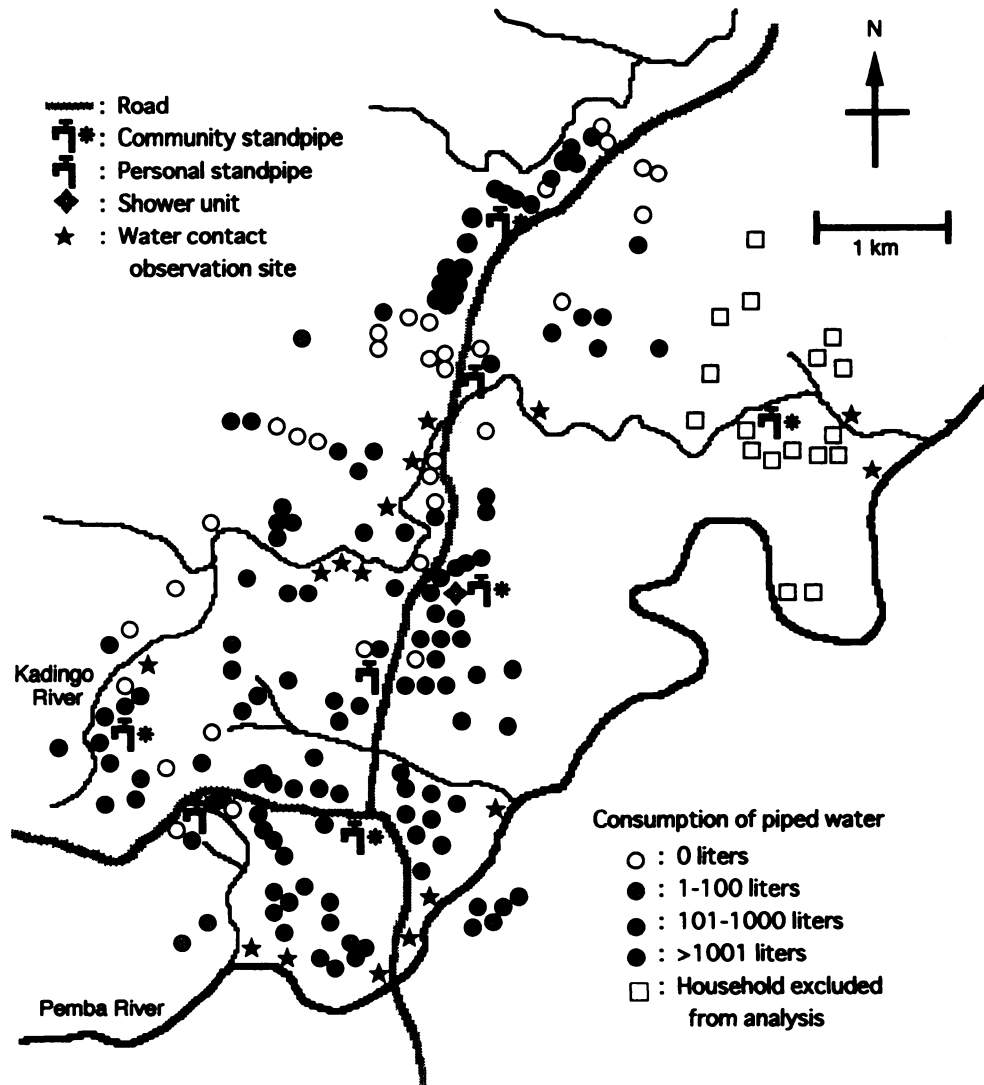


FIGURE 1. Map of study area, Mwachinga village, showing households and consumption of piped water.

each block covers June–September, October–January, or February–May, which we refer to as a block-season. The water contact study was started in June 1982 and continued for 48 months: 20 months (five four-month blocks) before, and 28 months (seven four-month blocks) after the installation of the piped water supply. A supervisor corrected simple mistakes in the collected data immediately after observation. The reliability of the data sent to our office was checked in two ways. First, the randomness of the data on duration of contact was checked under an assumption that the distribution of the duration of a behavior shows a negative exponential distribution. Then, the means of duration of each activity were compared between observers. To avoid seasonal influence, these examinations were carried out annually.

The level of water contact for one individual during a single exposure was expressed as duration of contact (minutes) multiplied by exposed body area (whole body = 1.0), which was estimated based on a calculation called the rule of nines. The total water contact of villagers for one four-month block (the amount of contact) was calculated as the sum of such contacts.

Statistical analysis. To assess the effect of the piped water supply, we compared the frequency and amount of water contact observed in a four-month block before and after provision of piped water, and we also compared the frequency and amount of water contact per person. When we made comparisons by type of activity, we analyzed only the frequency of contact, since several activities were often recorded at each contact.

Since sex, age, and season seemed to relate to water contact behavior, we took these three factors into account in the assessment of the effect of the piped water supply. A multiway analysis of variance (ANOVA) was applied with the main objective of assessing whether the frequency and amount of river water contact decreased after the provision of the piped water supply. This analysis was made separately by sex, based on a general linear model taking into account factors of age (separated into nine groups), season (each block represents a particular season), and period (before or after the provision of piped water). The general linear model SAS/STAT (SAS Institute, Inc., Cary, NC), which analyzes data within the framework of such a model, was used, and

TABLE 1
Frequency and amount of water contacts of males at 16 sites before and after provision of piped water

Period	Number of observed people	Frequency of contact	Frequency/person*	Total amount of contact†	Amount/person*	Population
Before water supply						
June 1982–Sep 1982	164	404	1.89	1,819	1.82	557
Oct 1982–Jan 1983	195	461	1.88	5,165	6.46	554
Feb 1983–May 1983	183	354	1.57	8,088	15.31	
June 1983–Sep 1983	196	455	1.80	4,104	2.81	561
Oct 1983–Jan 1984	157	299	1.58	4,165	8.10	561
Average	179‡	395‡	1.74§	4,668‡	5.30§	
After water supply						
Feb 1984–May 1984	96	203	1.74	1,825	4.25	
June 1984–Sep 1984	124	223	1.52	2,121	3.18	569
Oct 1984–Jan 1985	123	225	1.54	2,941	4.15	
Feb 1985–May 1985	135	235	1.48	5,299	12.81	
June 1985–Sep 1985	113	212	1.56	3,468	9.87	592
Oct 1985–Jan 1986	94	183	1.64	3,550	14.89	
Feb 1986–May 1986	114	176	1.35	2,767	7.40	669
Average	114‡¶ (63.7%)	208‡¶ (52.7%)	1.53§¶ (87.9%)	3,139‡¶ (67.2%)	6.89§ (130.0%)	

* Geometric mean of people observed in each period.

† The level of water contact for one individual during a single exposure was expressed as the duration of contact (min) multiplied by the exposed body area (whole body = 1) that was estimated based on a calculation called the rule of nines. The total water contact of villagers for one block was calculated as the sum of such contacts, and this value was the amount of water contact.

‡ Arithmetic mean of five or seven observation periods.

§ Geometric mean of all of the people observed before or after installation of water supply.

¶ $P < 0.05$.

the type II sum of squares was applied as a control hypothesis test.

To assess the effect of the piped water supply on water contact behavior more directly, we compared the decrease in the frequency of river water contact of each household with the consumption of piped water. A mean frequency of water contact per block by all the members of a household before and after the introduction of piped water was used to determine the rate of decrease in river water contact. The consumption of the piped water in the household was expressed as liters per person per year.

For statistical analysis, two-way ANOVA and regression analysis were applied with the main objective of assessing whether the frequency of water contact in a household decreased when members of the household consumed more piped water. We expected that the rate of decrease of the frequency of river water contact would also depend upon the frequency of contact before installation of piped water. Therefore, the frequency of water contact per person before installation was also taken into account.

RESULTS

Changes in number of observed people. Eight hundred seventy-nine of 1,230 inhabitants made river water contact at 16 observation sites during the period of the study. The average number of observed people making river water contact in four observation days in a four-month period (in a block) before the installation of piped water supply was approximately 30% of the total population, and there was no significant difference between sexes.

The results of frequency and amount of water contact for males and females are shown separately in Tables 1 and 2. The number of people observed in a block decreased in both sexes. These decreases were statistically significant both in

males and in females, even when the factors of age group and season were taken into account. The population increased at an annual rate of about 3% during this observation period.

Although the number of observed people did not differ according to the season, it differed significantly according to age in both sexes ($P < 0.01$). Therefore, subgroup analyses were made for age groups in each sex (Table 3). In males, the least square mean of the number of observed persons decreased in all age groups after the installation of safe water. However, the decreases were significant in the groups 0–4, 5–9, 10–14, 20–29, and 40–49 years of age. In females, the least square mean decreased in all age groups except in the age group 60 or more years of age. Significant changes were observed in the groups 0–4, 5–9, 15–19, 20–29, and 30–39 years of age.

Changes in frequency of water contact. Results are shown in Tables 1 and 2. The mean of total frequency of river water contact in a block showed a significant decrease both in males (47.3% reduction) and in females (41.2% reduction) after piped water installation.

The frequencies differed significantly according to age in both sexes ($P < 0.01$) but not according to season. The decrease of frequency in males significantly interacted with age group ($P < 0.01$), but that in females did not ($P > 0.05$). The decrease was observed in all age groups of males (Figure 2), although significant differences were not observed in groups 15–19 and 30–39 years of age. In females, a significant decrease was observed in the groups 0–4, 15–19, 30–39, and 50–59 years of age (Figure 3).

The frequency of water contact per person per block also showed a significant decrease both in males and in females after piped water installation. However, the decrease in frequency per person was not as steep as that of total frequency.

TABLE 2
Frequency and amount of water contacts of females at 16 sites before and after provision of piped water

Period	Number of observed people	Frequency of contact	Frequency/person*	Total amount of contact†	Amount/person*	Population
Before water supply						
June 1982–Sep 1982	159	410	1.92	1,894	2.30	651
Oct 1982–Jan 1983	201	540	2.01	6,348	7.41	634
Feb 1983–May 1983	167	381	1.77	4,372	8.74	
June 1983–Sep 1983	191	522	2.02	3,594	3.43	646
Oct 1983–Jan 1984	167	357	1.73	4,749	8.55	638
Average	177‡	442‡	1.89§	4,191‡	5.39§	
After water supply						
Feb 1984–May 1984	122	234	1.57	3,204	6.16	
June 1984–Sep 1984	117	277	1.84	2,326	2.88	658
Oct 1984–Jan 1985	106	242	1.81	4,542	9.43	
Feb 1985–May 1985	113	236	1.70	2,639	6.87	
June 1985–Sep 1985	118	267	1.86	2,774	6.32	723
Oct 1985–Jan 1986	114	255	1.76	3,379	8.59	
Feb 1986–May 1986	131	307	1.83	5,429	13.82	791
Average	117‡¶ (66.1%)	260‡¶ (58.8%)	1.76§¶ (93.1%)	3,470‡ (82.8%)	7.09§ (131.5%)	

* Geometric mean of people observed in each period.
 † See Table 1 for definition.
 ‡ Arithmetic mean of five or seven observation periods.
 § Geometric mean of all of the people observed before or after installation of water supply.
 ¶ $P < 0.05$.

The rates of decrease in the frequency of contact were only 12.1% in males and 6.9% in females.

The frequency per person varied significantly by age group ($P < 0.01$) and by season ($P < 0.05$) in both sexes. However, there were no interactions observed between these factors ($P > 0.05$). By subgroup analysis, significant decreases in the frequency per person were observed in males in the groups 10–14 and 60 or more years of age (from 1.85 to 1.49 and from 2.10 to 1.51, respectively), and in females in the group 50–59 years of age (from 2.25 to 1.64) ($P < 0.05$). The frequency per person did not differ significantly between any two seasons in either males or females. After piped water installation, a significant decrease was observed in the seasons of June–September and October–January ($P < 0.05$) in males, but not in females.

Changes in amount of water contact. The amount of water contact significantly decreased after piped water installation in males. It decreased also in females, but the change was not significant (Tables 1 and 2).

TABLE 3

Number of observed persons at 16 water contact sites for four months before and after provision of piped water

Age group (years)	Males		Females	
	Before*	After†	Before*	After†
0–4	9.3	4.2‡	16.0	4.2‡
5–9	35.7	17.4‡	30.6	20.1‡
10–14	42.0	26.5‡	26.5	20.5
15–19	19.7	17.0	18.2	11.7‡
20–29	24.5	15.8‡	31.7	19.8‡
30–39	14.8	11.9	22.5	16.3‡
40–49	17.8	10.1‡	11.0	7.7
50–59	8.3	5.7	13.2	9.4
≥60	7.5	5.2	5.7	6.8

* Arithmetic mean of five observation periods.
 † Arithmetic mean of seven observation periods.
 ‡ $P < 0.05$.

The amount of river water contact differed significantly according to age group ($P < 0.01$) and season ($P < 0.01$) in both sexes. Significant decreases in the amount of water contact in males were observed in the groups 0–4, 5–9, and 60 or more years of age (Figure 4). In females, a significant decrease was observed only in the group 0–4 years of age (Figure 5). Among the three seasons, the amount of water contact of males was highest in February–May and lowest in June–September, and the differences between the seasons were significant. The decrease in the amount of water contact after piped water installation in the season of June–September was not significant in males. In females, the amount of water contact was significantly lower in the season of

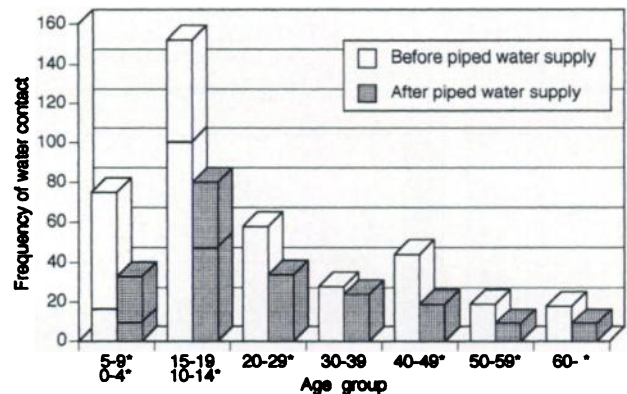


FIGURE 2. Frequency of water contact of males by age at 16 sites before and after provision of piped water. The value for before piped water supply is the arithmetic mean of five observation periods. The value for after piped water supply is the arithmetic mean of seven observation periods. The decrease was significant at the 0.05 level. The horizontal lines in the first two sets of bars separate the two age ranges indicated on the x-axis. The upper part of the bar indicates the older age range and the lower part of the bar indicates the younger age range.

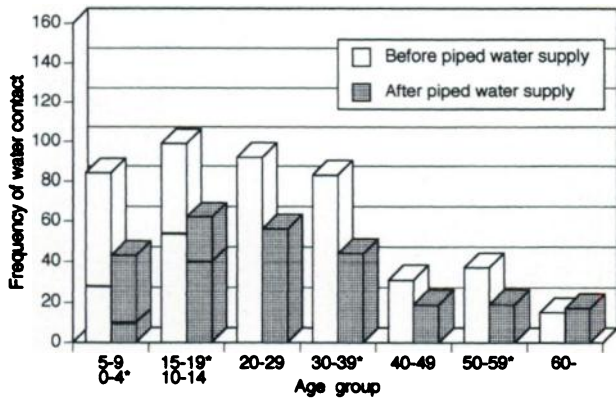


FIGURE 3. Frequency of water contact of females by age at 16 sites before and after provision of piped water. The value for before piped water supply is the arithmetic mean of five observation periods. The value for after piped water supply is the arithmetic mean of seven observation periods. The decrease was significant at the 0.05 level. The horizontal lines in the first two sets of bars separate the two age ranges indicated on the x-axis. The upper part of the bar indicates the older age range and the lower part of the bar indicates the younger age range.

June–September than in the other two seasons, and no significant decrease was observed in any season after piped water installation.

In contrast to the other indices of water contact, the geometric mean of the amount of river water contact per person per block did not decrease after piped water installation, but increased from 5.30 to 6.89 in males and 5.39 to 7.09 in females (Tables 1 and 2). However, the difference was not significant in either sex when age group and season were taken into account.

The geometric mean of the amount of water contact per person differed significantly by age ($P < 0.01$) and by season ($P < 0.01$) in both sexes. By subgroup analysis, the change in the geometric mean of the amount per person was not significant in any age group in either sex. Although the

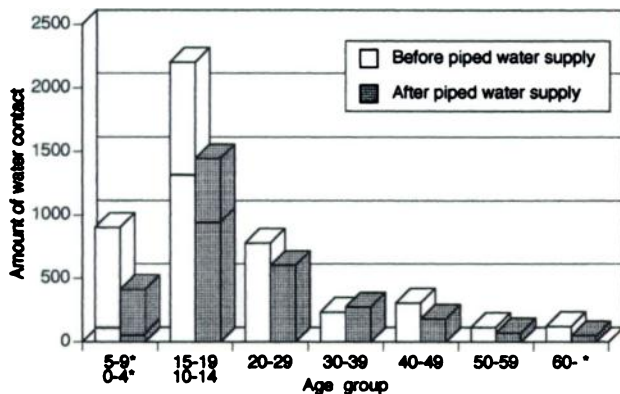


FIGURE 4. Amount of water contact of males by age at 16 sites before and after provision of piped water. The value for before piped water supply is the arithmetic mean of five observation periods. The value for after piped water supply is the arithmetic mean of seven observation periods. The decrease was significant at the 0.05 level. The horizontal lines in the first two sets of bars separate the two age ranges indicated on the x-axis. The upper part of the bar indicates the older age range and the lower part of the bar indicates the younger age range.

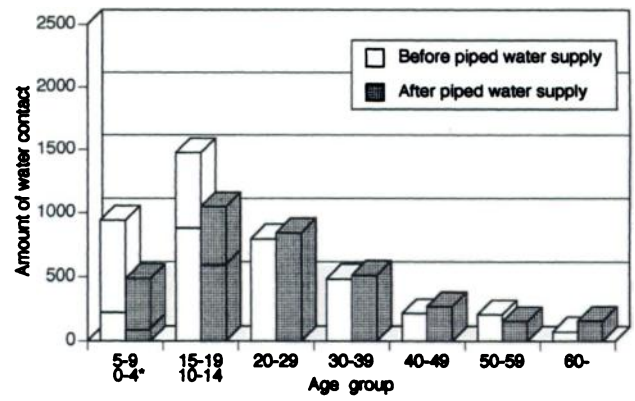


FIGURE 5. Amount of water contact of females by age at 16 sites before and after provision of piped water. The value for before piped water supply is the arithmetic mean of five observation periods. The value for after piped water supply is the arithmetic mean of seven observation periods. The decrease was significant at the 0.05 level. The horizontal lines in the first two sets of bars separate the two age ranges indicated on the x-axis. The upper part of the bar indicates the older age range and the lower part of the bar indicates the younger age range.

degree of the changes in the amount of water contact per person were not different among the three seasons in females and were not different among age groups in both sexes, the degree of the changes were significantly different among the seasons in males ($P < 0.01$). In the season of June–September, the geometric mean of the amount of water contact increased significantly from 1.86 to 4.17, whereas it decreased in February–May from 13.22 to 6.13. Although the mean amount in females increased in all seasons, the changes were not significant.

Changes in water contact frequency by activity. We categorized community activities as shown in Tables 4 and 5. We divided the activity of washing clothes into two types: washing in the river and washing by the river, since the total frequency of river washing did not change significantly, but our impression was that the washing activity changed after piped water installation. In both sexes, the total frequency of water contact per block decreased significantly after piped

TABLE 4

Water contact frequency in four observation days in a four-month period at 16 sites before and after provision of piped water

Activity	Males		Females	
	Before*	After†	Before*	After†
Washing clothes in the river	20.0	10.9‡	55.6	34.4‡
Washing clothes on the riverbank	4.6	7.3	19.2	30.3
Washing utensils	2.6	2.6	19.8	19.3
Bathing§	178.8	111.4‡	164.6	115.9‡
Washing the body¶	52.2	21.6‡	87.2	36.1‡
Collection of water	13.6	15.3	199.0	133.1‡
Playing	34.0	20.3‡	22.0	8.3‡
Fishing	47.0	31.9	19.8	15.4
Drinking	23.0	5.4‡	11.0	3.6‡
Others#	126.4	78.3‡	95.2	54.0‡

* Arithmetic mean of five observation periods.

† Arithmetic mean of seven observation periods.

‡ $P < 0.05$.

§ Water contact with the entire body or the body except the head.

¶ Water contact with body parts.

Crossing the river, watering animals, and unspecified activity.

TABLE 5

Water contact frequency per person on four observation days in a four-month period at 16 sites before and after provision of piped water*

Activity	Males		Females	
	Before†	After‡	Before†	After‡
Washing clothes in the river	1.48 (n = 62)	1.76§ (n = 41)	1.39 (n = 183)	1.63§ (n = 135)
Washing clothes on the riverbank	1.28 (n = 17)	1.69§ (n = 29)	1.19 (n = 76)	1.93§ (n = 100)
Washing utensils	1.15 (n = 10)	1.09 (n = 16)	1.11 (n = 85)	1.10 (n = 117)
Bathing¶	1.37 (n = 566)	1.26§ (n = 554)	1.35 (n = 543)	1.34 (n = 535)
Washing the body#	1.21 (n = 196)	1.13 (n = 127)	1.23 (n = 322)	1.16 (n = 204)
Collection of water	1.17 (n = 54)	1.25 (n = 76)	1.67 (n = 474)	1.68 (n = 460)
Playing	1.13 (n = 141)	1.20 (n = 109)	1.13 (n = 92)	1.07 (n = 53)
Fishing	1.25 (n = 169)	1.20 (n = 172)	1.13 (n = 84)	1.07 (n = 99)
Drinking	1.13 (n = 95)	1.03 (n = 36)	1.17 (n = 44)	1.04 (n = 17)
Others**	1.51 (n = 348)	1.47 (n = 313)	1.71 (n = 223)	1.62 (n = 203)

* n = total number of the people observed in five observation periods before provision of piped water and in seven observation periods after provision of piped water

† Geometric mean of data in five observation periods.

‡ Geometric mean of data in seven observation periods.

§ P < 0.05.

¶ Water contact with the entire body or the body except the head.

Water contact with body parts.

** Crossing the river, watering animals, and unspecified activity.

water installation in the activities of washing clothes in the river, bathing, washing the body, playing, and drinking. In females, the frequency of collection of river water also decreased significantly (Table 4).

In contrast to total frequency, the frequency per person decreased significantly only in male bathing (Table 5). Also, in contrast to total frequency, the frequencies per person in the activities of washing clothes both in and by the river increased significantly in both sexes. The frequencies per person of other activities did not change significantly.

Piped water consumption. Of a total of 186 households in the village during the study period, 20 used one community standpipe for which the records were not complete. None of the members of 33 of the 166 remaining households appeared in the record of piped water consumption at the other four standpipes. Fourteen of the 33 households were located next to several private taps, which were constructed either before or at the same time we introduced standpipes. The water contact frequency per person per block in the 33 households decreased dramatically, from 0.46 to 0.16, although they did not use the community standpipes at all in the period, whereas the frequency per person in the other households decreased only from 0.62 to 0.46. Some of the 33 households might not have used the piped water at all, but most of them seemed to use a neighbor's tap water. Therefore, we excluded the households that were not recorded at the community standpipes from the analysis.

The maximum amount of piped water consumption per year in a household was 25,780 liters and the minimum was 20 liters. The geometric mean was 1,752 liters per year. The maximum amount per person per year was 5,960 liters, the

minimum was 2.5 liters, and the geometric mean was 307 liters per year. The consumption of piped water per person correlated negatively with the number of members in a household (Table 6) and with the distance to community standpipe (Figure 6), but it did not correlate with the distance to the river (Figure 7).

Piped water consumption and change in frequency of river water contact. The consumption of piped water per person and the change in frequency of river water contact in a household are shown in Table 7. Our analysis was made on 124 of 133 households since no members of nine households had been observed in contact with the river before the installation of piped water.

We divided the households arbitrarily into three groups according to the volume of water consumption: those that used more than 1,000 liters of piped water per person per year, those that used 1,000 liters or less but more than 100 liters, and those that used 100 liters or less. The water contact frequency decreased to less than half in the households that used more than 1,000 liters per person per year. However the rates of decrease were very small in those that used 101-1,000 liters and in those that used less than 100 liters. In households with a high consumption of piped water, the

TABLE 6
Number of members per household and piped water consumption

Number of members	Number of households analyzed	Consumption of water (liters/person/year)
1-2	13	554*
3-5	41	496*
6-8	42	301*
≥9	37	150

* The differences among these values are not significant at the 0.05 level (Scheffe's test).

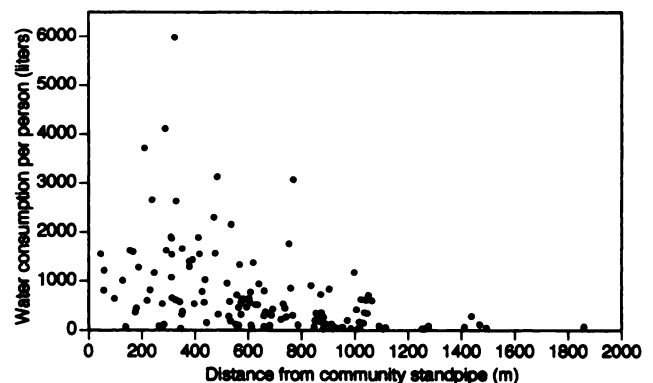


FIGURE 6. Relationship between consumption of piped water and distance to the taps. The regression equation is Y (consumption of piped water in liters per person per year in log) = -0.001135X (distance in meters) + 3.23 r² = 0.3212.

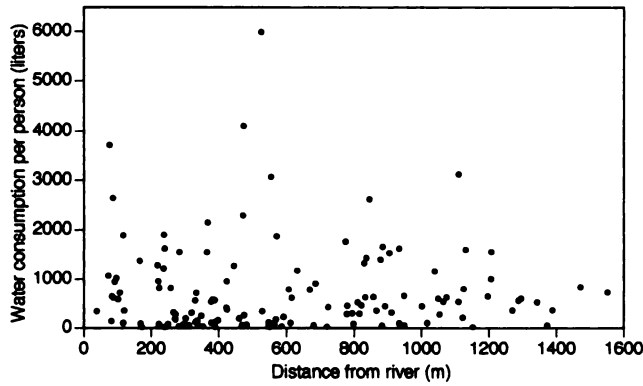


FIGURE 7. Relationship between consumption of piped water and distance to the rivers. The regression equation is Y (consumption of piped water in liters per person per year in log) = $0.000176X$ (distance in meters) + 2.38 $r^2 = 0.0091$.

frequency of water contact per person per block showed a significantly greater decrease than in those with low consumption of piped water.

The rates of decrease also differed significantly according to the frequency of contact before piped water installation ($P < 0.01$). However, the frequency of contact before piped water installation did not relate to piped water consumption.

DISCUSSION

In the present study, the ultimate purpose of providing a safe water supply was to reduce infection with *Schistosoma haematobium*. To evaluate the impact of the safe water supply, it would be necessary to record changes in *S. haematobium* infection in the area. In our study area, mass chemotherapy with metrifonate was carried out together with the introduction of piped water in February 1984. The selective mass chemotherapy with metrifonate caused a 79.8% reduction in the intensity of *S. haematobium* infection and a sharp decrease in the prevalence of gross hematuria from 18.3% to 5.1%, although the overall prevalence of hematuria was reduced only slightly from 67.4% to 54.0%.¹⁹ However, it is also important to record how people change their behavior after safe water becomes available because the reduction of the infection rate depends on the reduction of contact with infested water.

There are several reports that a water supply system that is either communal or household lowers the degree of infested water contact in a community. The difference in the degree of water contact between patients who lived in homes with and without a piped water supply was examined in an area endemic for *S. mansoni* in Brazil.⁹ The geometric mean of the degree of contact with infested water was significantly higher in individuals without piped water in the house than in those with piped water (96.8 versus 25.7 for the whole population). In the villages of St. Lucia, which provided safe water to the households, the total number of observed contacts with infested water was reduced by 68% in a 15-month observation period.²⁰ It was shown in some other endemic areas that the communal provision of safe water also had a significant impact on the infested water contact and schistosomiasis infection. In Ethiopia, the number of water contacts

TABLE 7

Piped water consumption and change of frequency of water contact

Consumption of water (liters/person/year)	Number of households analyzed	Rate of water contact (after water supply/ before water supply)
1-100	30	0.85*
101-1,000	65	0.80*
>1,000	29	0.43

* The differences among these values are not significant at the 0.05 level (Scheffe's test).

with the local stream significantly decreased, especially for fetching water and washing clothes, after the installation of a piped water system.¹² In Brazil, laundry facilities, a communal water supply obtained from a dug well, latrines, and health education were shown to reduce the prevalence of the disease.³ In Egypt, even the partial use of safe water from public water standpipes markedly lowered the prevalence of *S. mansoni* and *S. haematobium*.² However, in an endemic area of Coast Province, Kenya, it was demonstrated that supplying safe water via communal wells had little impact on the prevalence of *S. haematobium*.¹¹ In an endemic area in Brazil, the factors found to be independently associated with *S. mansoni* infection were age, water contact for agricultural activities, fishing, and swimming or bathing. The infection rate was not influenced by whether people had piped water, a well, or an unsafe water supply.⁹

Few reports have examined the impact of a safe water supply on the water contact behavior of inhabitants. We observed that the number of people with infested water contact, the total frequency of river water contact, and the total amount of such contact decreased significantly after piped water installation: a 35.1% reduction in the number of observed people, a 44.1% reduction in the total frequency of contact, and a 25.4% reduction in the total amount of contact. However, the reduction in the frequency of contact per person was only 12.1% in males and 6.9% in females, although this reduction is significant. The amount of water contact per person increased from 5.30 to 6.89 in males and from 5.39 to 7.09 in females. The total frequency decreased in almost all activities. However, the frequency per person increased significantly for washing clothes (washing clothes in the river: from 1.48 to 1.76 in males and from 1.39 to 1.63 in females; washing clothes by the river: from 1.28 to 1.69 in males and from 1.19 to 1.93 in females). All these facts imply that the reduction of water contact was mainly due to the decrease in the number of people coming to the river. The people who continued using river water actually increased, but not significantly, their amount of water contact. The impact of the piped water supply was only on a limited number of people who almost completely stopped using river water and therefore were not recorded in our water contact study. These results show that piped water reduced the contact with infested water at the community level. However, the results also indicate that the effect of the water supply on the water contact behavior of villagers was heterologous: i.e., the piped water supply had a great influence on some of the inhabitants in the area but very little on the rest.

The influence of a safe water supply on the various types of water contact activity depends on many factors, such as the type of water supply, quantity and quality of water, and

the facilities prepared (laundry tubs, taps, and showers). In a neighboring district of our study area, for example, bore-hole wells were introduced in some villages and the impact on water usage was assessed by questionnaires.¹¹ The study area was located on low land where the main high-risk water sources were ponds and marshes and vector snails were different from those found in our study area. Following introduction of wells, there were significant decreases in the use of high-risk water for drinking, cooking, and dish washing, but not for bathing and clothes washing. However, in our study area, the impact of a piped water supply on bathing was significant. This difference was probably due to the shower unit installed in our study area.

The impact in our study area was almost equal on both sexes and on each age group, although a little greater in younger age groups. Our water supply system did not have much effect on major domestic activities such as washing clothes and washing utensils, probably because of the lack of laundry facilities. The activities of washing clothes and utensils were not major activities of children. The shower unit was provided especially for school children free of charge. Thus, it was not surprising that a relatively greater reduction was observed in children than in adults. Fetching water and washing clothes are major activities for women. The impact seemed to be less in females than in males, although the sexual difference was not significant except for the total amount of contact.

Our data indicate that the people using piped water had less contact with river water. A significant decrease was seen only when people used more than 1,000 liters per person per year. In these cases, the frequency of river water contact in the household decreased to less than half of that in the period before the installation of piped water. In our study, using less than 1,000 liters of piped water per person per year was insufficient in reducing contact with river water significantly. It is likely that meaningful replacement of river water sources with safe water occurs only when people use a certain quantity of safe water.

One of the factors determining the consumption of piped water was the distance from the home to the taps. The limited number of community standpipes for a dispersed population restricted usage. In this village, only 35% of the households are located within 500 m of community standpipes, and 70% of the households are located within 1 km. The construction of more standpipes would be a solution to this problem. The requirement for immediate payment for water and the lack of facilities for washing clothes also seemed to be factors that prevented further reduction in contact with infested water. In Ethiopia, household surveys showed that the use of stream water continued after the installation of the piped water system, due to the high cost of piped water, frequent breakdowns of the pump, and a preference for stream water for washing clothes.¹⁴

It is interesting that the activities of bathing decreased both at the communal and individual levels, even though only one shower unit was constructed in a school, and that mainly for the pupils. Also, people changed their washing place dramatically from streams to riverbanks without educational efforts. The actual presence of the control activity probably worked as an educational tool for the control of schistosomiasis in the village.

The results of this study indicate that a safe water supply is not always used by all of the inhabitants of an area. To overcome the heterogeneity of the reduction of water contact, the construction of more community standpipes, the provision of laundering facilities, and systematic health education would be necessary.

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