Water And Health In Rural Malawi

Aspects Of The Performance, Utilization And Health Impact Of The Malawi Self-Help Rural Water Supply Project

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of the Malawi Self-Help Rural Water Supply Project

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EXECUTIVE SUMMARY

1. Background:

This report presents the results of a series of studies designed to assess the performance, utilization and health impact of the USAID-funded Malawi Rural Water Project. The study was designed in late 1984; field work was carried out from November 1984 to July 1985; analysis and report writing were done from August 1985 to February 1986. The studies were funded by USAID/Malawi and executed in conjunction with the Department of Water and the Ministry of Health of the Government of Malawi.

The major purpose of this evaluation was to assess the health impact of the Project. Before health impacts can be expected of a water project, it must be shown that the systems perform adequately and are used appropriately by the villagers. Since these aspects are also of major interest to the staff of the Project, this evaluation also addressed performance and utilization issues. The performance and utilization evaluations drew on existing data supplemented by data on water use and water quality collected from a project in the South (Zomba East) and a project in Central Malawi (Champira North). The health impact evaluation was designed to estimate the relative risk of diarrhea in young children whose families used the piped water rather than traditional water supplies in one specific area (Zomba East).

2. Performance Evaluations:

Reliability:

Due to the excellent monitoring, maintenance and repair system, the water supplies are reliable. An assessment of 9 rural piped systems showed that, except in the few instances of major pipeline repairs, water was delivered in sufficient quantities from each tap 90% of the time.

Quantities of Water Delivered:

The rural piped systems have been designed to deliver 27 litres per capita per day (a figure recently increased to 36 lcd). Actual quantities of water which are delivered have been measured by installing meters in several projects. These analyses show that the systems deliver between 10 and 30 lcd. Demand was generally less than the design figure of 27 lcd, so the capacity of the systems was generally adequate.

Convenience:

In the Zomba East Project during the study period (viz. the rainy season) traditional surface water sources are abundant. The piped water supplies are no more convenient than the traditional supplies during this period. There were no appreciable time savings due to the improved supply.

In the Champira North Project area, traditional sources are not so readily available. The introduction of the piped water supply has reduced the distance and time spent fetching water by more than 50%.

Water quality:

The bacteriological quality of water was measured in the Zomba East Project. As shown in Table I, the quality of water delivered through the piped supplies is much better than the quality of water at the traditional sources.

Table I: Bacteriological quality of water at the source: (geometric mean of fecal coliforms/100ml)

SOURCE	Piped water	Borehole	Unprotected wells and river
QUALITY	12	46	540

Conclusions on Performance:

The piped water supplies deliver adequate quantities of water of good bacteriological quality with a high degree of reliability.

3. Utilization Evaluations:

Choice of water supply:

In the Zomba East Project during the study period (viz. the rainy season) the piped water supplies are no more convenient than the traditional supplies. Of those using the improved supplies for drinking and cooking, about half continued to use traditional sources for clothes washing. In areas where traditional sources are readily available consideration should be given to increasing the density of taps (i.e. reducing the design distance from 400 meters) so that villagers would be encouraged to abandon the traditional supplies for all domestic purposes.

In the Champira North Project area, where traditional sources are not so readily available, 96% of families used the improved supplies for all purposes, including bathing and clothes washing. In dry areas (such as Champira North) the existing design distance is sufficient to induce a complete switch to improved sources. An analysis of the determinants of the quantity of water used shows that the quantities used would increase only slightly if the taps were closer to the homes.

Water handling:

In many settings it has been shown that the bacteriological quality of water consumed in the home depends primarily on contamination in the home and not on quality at the source. In Zomba East information on water collection and storage practices was obtained and showed that most women had adopted hygienic practices (storing water inside the house in covered containers, and using a cup with a handle for dipping water out of the container). Detailed analyses were also conducted of water quality at the source and in the home. These data (Table II) show that, in this particular area, source quality is the primary determinant of quality of water consumed, and that those who use piped water consume much better quality water than those using water from traditional sources.

Table II: Bacteriological quality of water at the source and in the home (geometric mean of fecal coliforms/100ml)

	Piped water	Borehole	Unprotected wells and rivers
Quality at source:	12	46	540
Quality at home:	16	240	760

Conclusions on Utilization:

The utilization of these supplies is generally good. One improvement which could be made is to increase the density of taps in areas in which traditional supplies are readily available. In the Zomba East area at least, water collection and storage practices are good, ensuring that the quality of the piped water is maintained.

4. Health Impact Evaluation:

Study site and method

A case-control study was conducted in the Zomba East project area to assess the effect of the project on severe diarrhea in the peak diarrhea season. Cases were children under five who reported to the clinic because of diarrhea, while controls were children under five who reported to the clinic for a set of other complaints but did not have diarrhea. A total of about 800 children were recruited. Information on water supply and sanitation conditions and other factors potentially affecting the health of the child were collected through interviews at the clinic and in the home.

Results

Etiologies: Stool samples and rectal swabs were collected from some cases and controls and tested for diarrhea pathogens. Isolation rates are shown on Table III:

Table III: Diarrhea pathogens isolated from stools

	Viruses	Bacteria	Parasites
Cases	17%	27%	25%
Controls	0%	27%	10%

Protective effect of water supply and sanitation improvements:

The results of the epidemiologic study are best presented by means of a scenario which depicts a progression from the "worst situation" of an unprotected water supply and no latrine, through the "first step" of an improvement in either water supply or excreta disposal to a "best situation" in which both an improved water supply and a latrine are used. From the analysis of the data, there are two main conclusions:

(i) The reduction in the risk of diarrhea as a result of the "first improvement" alone (either water supply or a latrine) is much less (typically by a factor of 2 to 4) than the reduction as a result of the "second improvement);

(ii) As may be expected given (i), the effect of improvements in water supply and excreta disposal are greatest when the other major source of transmission of fecal-oral pathogens (viz. contaminated food) has been eliminated (through breastfeeding). The results show that the effects on diarrhea of improving both water supply and excreta disposal is about 4 times greater for those who are exclusively breastfed than for those who are fed supplements.

There are major epidemiological and policy implications of these findings.

Epidemiologic Implications: As expected from theoretical considerations, in an environment in which there are multiple routes of transmission of fecal-oral pathogens, improvements in just one route, even the most important route, will have little direct impact on disease. The lack of direct impact notwithstanding, such "first-step" improvements (such as water supply) are important health interventions, since it is on the basis of these apparently-ineffective interventions that subsequent interventions (such as excreta disposal and food hygiene) can be successful in reducing disease.

Policy Implications: The results show the need for health interventions which couple improved environmental services and hygiene. A coordinated program for improving water supply, excreta disposal and food hygiene has the greatest potential for measurable success in reducing the incidence of diarrhea. The decision by the Government of Malawi and USAID to couple water supply programs with excreta disposal and hygiene education programs is clearly a wise choice and should be continued.

Generalizing the findings of the Zomba East study to other areas of Malawi

In assessing the impact of piped water supplies on health in Malawi, three different categories of disease might be affected. First, if the bacteriological quality of water used for drinking and cooking is improved, this will reduce exposure to water-borne diseases (such as some diarrheal diseases). Second, if the quantity of water used for personal hygiene is increased, a reduction in water-washed diseases (such as some eye diseases and some diarrheal diseases) is expected. And third, where direct contact with contaminated surface water is reduced, a reduction in water-based diseases (such as schistosomiasis) is anticipated.

The epidemiologic study was conducted only in Zomba East. In this particular project improvements were limited to changes in water quality (since there was no change in either quantity of water used or water contact). In many other rural piped water projects in Malawi (such as Champira North) improvements in all three aspects (viz. quality. quantity and water contact) have taken place. The impact on diarrheal diseases of the piped water project in Zomba East should thus be regarded as defining a lower limit on the overall health impact of a rural piped water project in Malawi.

Conclusions on health impact:

In the study area it has been shown that improving water supply or excreta disposal practices alone has little effect on diarrheal diseases in young children. It has also been shown that where such improvements are made together, there are substantial health benefits, and that these benefits are still larger if food hygiene practices are improved. In most other rural piped water supply areas it is expected that the health benefits will be the same or even greater than those shown for the study area.

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INTRODUCTION

This report presents the results of several separate evaluation activities on the Malawi Rural Piped Water Project funded by the U.S. Agency for International Development. USAID has provided $6 million (1980-1985) to support the Government of Malawi's long established rural piped water program, through construction of 16 new systems, provision of staff salaries and the inclusion of an expanded health education and sanitation program in the water project areas. The USAID project proposal called for a certain amount of evaluation activities and it is under this provision that the current studies were undertaken.

USAID Contract CO-612-0000-5-50003 was established so information would be available for the final USAID evaluation, scheduled mid-1986, in the following areas:

1. Performance and utilization of the rural piped water projects;
2. Health impact of the rural piped water projects.

Impact evaluation should only proceed for projects known to be correctly functioning and well utilized. The World Health Organization has suggested in the "Minimum Evaluation Procedure for Water Supply and Sanitation Projects" (1) a sequence of approach for evaluation. As shown in Figure 1, determinations are to be made first that the water supply and sanitation facilities, along with health education, are functioning as intended. Then after proper use of the facilities is ascertained, an evaluation of health, social or economic impacts can be appropriately undertaken. The performance and utilization evaluations performed under this contract supplement other available information on the rural piped water project. The health impact evaluation is one of the first attempts to quantify such benefits of this program.

Approximately 25-30% of the contract time has been spent on the performance and utilization evaluation. This included the review of existing reports by the Water Department, Centre for Social Research and Central Water Laboratory. When useful unreported data were available, they have been interpreted and included in this report. The areas of evaluation for performance and utilization covered include quantity of water provided and used, system reliability, convenience and water quality. In addition, because most available data are from the well established projects in the southern region of Malawi, it was decided to collect data from one of the new, USAID-funded projects in the northern region of Malawi. A water collection and sanitation survey in the USAID-funded Champira North project was conducted, and provides details on water and latrine use and their determinants. The performance and utilization results are presented in Sections 1 and 2 and the Champira survey in Section 3.

The main focus of the health impact evaluation was an epidemiological study, the objective of which was to estimate the relative incidence of diarrhea in young children who use piped water

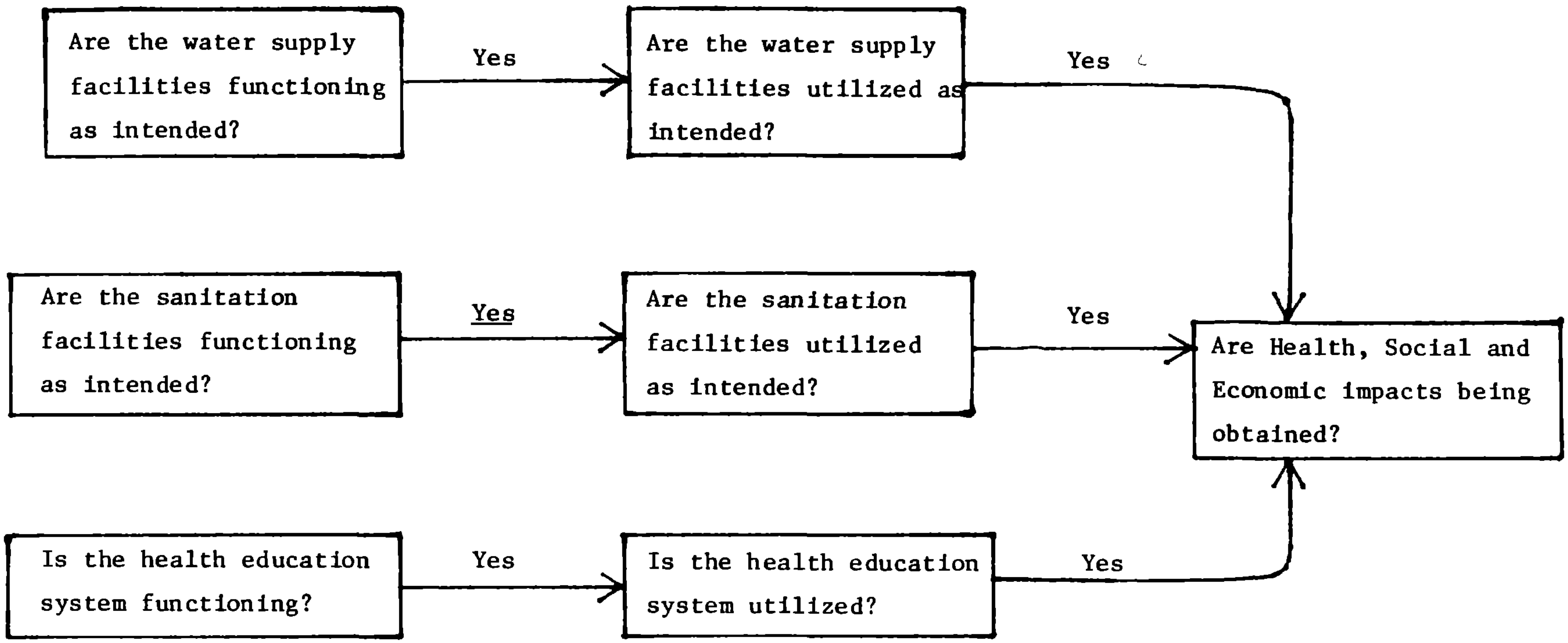

Figure 1. Approach to Water and Sanitation Project Evaluation (adapted from WHO Minimum Evaluation Procedure (1))

rather than traditional water supplies. Six months of field work - preparation, training, and collection of data - took place in and around Zomba East piped water project. Eight hundred and forty children were studied. The results of this are presented in Section 4. Other health effect information extracted from existing reports is presented in Section 5.

1. PERFORMANCE AND UTILIZATION OF PIPED WATER SYSTEMS

1.1 Water Quantity

1.1.1 How is this measured?

There are two water quantity measures of interest: the quantity flowing through the distribution system which may be considered production, and the quantity actually used by the population, which is consumption. Production is measured by meters placed inline in the distribution system. It reflects all water delivered to the taps and any excess flow due to pipeline leaks. Consumption is measured by enumerators determining daily household collection of water from the taps. Such values do not include water used at the tap for rinsing or water spilled, or any leaks whether before or at the tap. Consumption quantities necessarily will be less than production quantities unless there is no wastage or leakage.

Both measures are important. The meter readings serve our purpose best if we wish to know the total amount of piped water needed to serve a population, which must include allowances for a certain amount of leakage or wastage. But enumerator observations provide greater insight to household variations in water use and the amounts people actually use for their personal activities.

1.1.2 How much are systems providing?

Several metering programs have been conducted by the Rural Piped Water Program during the last few years to determine the per capita production in various rural piped water systems. The systems had been designed to provide 27 litres per capita per day (lcd) and are now designed for 36 lcd. By installing meters in the pipelines and taking daily or weekly readings, a production figure based upon the known or estimated population may be calculated. Table 1 presents the production figures developed for 5 water projects.

As the figures for litres/capita/day show, there is a wide variation in the amount supplied, ranging from 5.6 lcd in Zomba East to 34.5 lcd for Line A in Lifani. These production figures are accurate only so far as the population figures, usually projections based upon an earlier census, are correct. However, they do indicate general trends for the projects.

The Nalipili project was designed for 18 lcd, rather than 27, due to a limited water supply. The project, constructed between 1978 and 1980, had almost reached its design capacity in 1983 when the production figure of 17.2 lcd was calculated. Mr. van Schaik's analysis shows that the distribution of water over the supply area accurately follows the design flows with lower amounts being delivered to the areas near rivers (Kangoma, Wasi, Sambala, Makwale) while the mainline taps distant from rivers provide considerably more per capita.(2) In Mulanje West, a project 10 years old now, the supplied amount was an average 19.0 lcd in

Table 1

WATER PRODUCTION: METERING

PROJECT/ LINE OR TAP	METERING DATES	AVG. PRODUCTION LITRES/CAPITA/DAY	SOURCE OF DATA
Nalipili/			
Master Meter(72)*	11/82-5/83	17.2	DLVW:
Chilingulo(9)		17.3	van Schaik
Ekhamuna (3)		16.0	7/82 (2)
Makwale 1(5)		9.8	
Makwale 2(3)		10.6	
Salamba(9)		15.6	
Bwanali(5)		17.3	
Wasi(11)		10.2	
Kangoma(7)		4.8	
Mulatho(25)		13.7	
Mainline taps(27)		34.2	
* (number of taps)			
Mulange West	1/82-5/82	19.0	DLVW: van Schaik 7/83 (3)
Nalipili	1/81-6/82	10.3	CSR: Ettema 1983 (4)
Zomba East/	9/82-3/83		Water Dept.
Mulangali		5.6	Evaluation
Mwaluka		7.7	Files
Tabu		8.4	Compiled by
Godfrey		9.0	Young. 6/85
Lifani/			
Mainline A	7/84-9/84	20.8	Water Dept.
Line A		34.5	Easton,
Line B		20.0	1985 (5)
Line C		21.8	
Line D		14.0	
Line E		13.1	
Chingale	5/85	17.0	Water Dept. unpublished data Easton, 1985

1982.(3) The average flow in the system was 85% of the design flow of 300 gpm. Mr. Van Schaik estimated that the design capacity would not be reached until 1990. So here we have examples of one project which has quickly reached its capacity in 4-5 years and another which may reach capacity after 15 years.

The other Nalipili production data was reported by Dr. Wim Ettema of the Centre for Social Research in the report "The Rural Piped Water Evaluation Programme: Some Baseline Data and Recommendations".(4) The 18 month average from January, 1981, to June, 1982, was 10.3 lcd. This figure was based upon meter readings and population figures provided by DLVW. The 10.3 lcd figure falls in line with the production observed in 4 Zomba East villages in 1982-83. The 4 villages had production figures ranging from 5.6 to 9.0 lcd. Dr. Ettema had excluded the previous 1981-82 Zomba East meter readings in his report due to missing and/or questionable readings. The contractor found, upon further examination of the files, that the metering had been extended into 1983 for several villages. Those files with complete reporting and reliable population estimates were analyzed. These figures may be lower than those of Nalipili and Mulanje West because they reflect only flow at single taps when no breaks or leaks were reported. A mainline or distribution line meter will record all flow through the distribution including leaks due to pipeline breaks and will usually show production to be higher than actual consumption.

The 1984 metering of the Lifani project found a general production rate of 20 lcd with a range of 13.1-34.5 lcd.(5) The high consumption was in a trading centre where population may have been underestimated and/or where business activities sustain higher use. Currently the project is operating at 71% of design capacity and it is estimated that by 1990 the demand will still be 20% below capacity. In Chingale project, the first rural piped water scheme built in Malawi, production was metered in May, 1985, at 17.0 lcd.

In all these projects, production was generally less than the design figures of 27 or 36 lcd, so the capacity of the systems was adequate when metered. Projections of demand have forecast potential shortfalls in specific areas or projects, but these are the exception rather than the rule.

Metering flow is a fairly simple activity, neither labour nor time intensive, which provides quick feedback on both production and performance. Especially as projects age, they should be metered to see what capacity remains and if supplies should be supplemented. The Water Department is currently metering several USAID funded water projects and has plans to monitor 8 projects within the next year.

1.1.3 How much are people using?

Another method of measuring consumption is to observe what people are using in or carrying to their homes. Although this measurement does not account for water used at the tap or lost in line breakages, it does reflect the variations in household water use due to carrying distance, social and economic factors. Several studies have measured this in a variety of ways. The results are summarized in Table 2 and discussed below.

The most comprehensive examination of water use was conducted by the Centre for Social Research in the 1981 survey of Zomba East and Zomba South.(6) Observations and measurements were made on all water collected and carried from the tap from 5 am to 6 pm during 2 days at each of 36 taps. The average collected was 10.6 lcd. (This does not include what people used or spilled at the tap.)

Four villages in Zomba East had been surveyed earlier that year by DLVW along with 11 villages in the Mulanje area. Similar measurements were made at the taps, but over a 7 day period in each village. Dr. Ettema analyzed these data and found an average 13 lcd used in Zomba East and 9 lcd in Mulanje.(4)

Dry-season and wet-season surveys of Chidothe village in Chagwa project showed average consumption over a 5 day period to be 20.3 lcd in August '82 and 18.1 lcd in February '83. These figures were calculated by the contractor, averaging the lcd for each household (range 1.6 - 60.0 lcd) rather than computing an average from the total volume collected in the village divided by the total number of villagers. Had the calculations for Chidothe been made using the second method, the figures would be 18.8 lcd for August and 15.1 for February. Both of these figures are lower than the first set indicating that there are several high volume households bringing up the overall average. Small households usually have a higher per person consumption than larger households due to economies of scale when fetching water. This is important when considering design using peaking factors as will be discussed later.

In the May, 1985, survey of 336 households using taps in the Champira project, an average household use of 19.9 lcd was measured. The method of estimation was to measure the dimensions of pails, buckets, etc. used to collect water and inquire how many of each were collected a day. Then a volume per container and total volume/house were calculated. Other village surveys have shown that day-to-day household use varies, and we feel that the women reported high rather than average use days. Thus this method probably yields a high estimate. The figure compares reasonably with the Chidothe estimates which were obtained from volumetric measurements at the tap, but is about twice the amount estimated for Zomba East and Mulanje.

1.1.4 How do we interpret these figures?

As indicated earlier, production figures should be higher than consumption since they include water distributed but not totally consumed. When we compare the two sets of results on production and consumption, one from metering and the other from village or household observations, we see that the two are not greatly different. Metering

TABLE 2

WATER CONSUMPTION: HOUSEHOLD SURVEYS

PROJECT/TAP	SURVEY DATES	AVERAGE CONSUMPTION LCD	METHOD OF MEASUREMENT	SOURCE OF DATA
Zomba East	8/81	10.6	2 days of observation at each of 36 taps	CSR: Msukwa, 12/81 (6)
Mulanje	1981	9	7 days observation at each of 7 taps	CSR: Ettema,83 (4)
Zomba East	5-6/81	13	7 days observation at each of 4 taps	CRS: Ettema,83 (4)
Chagwa/				
Chidothe	8/82	20.3	5 days observation at tap	Water Dept. Files; Young
Chidothe	2/83	18.1		
Champira	5/85	19.9	household visits in random sample	Easton/ Young (7)

has provided a range of values from 5.6 to 34.5 with the majority between 8 and 22 lcd, and enumerator estimates are between 9 and 20.3 lcd. Figures are generally higher for master meter and mainline readings and lower for single villages, except for trading centers which have commercial as well as residential water use.

Mr. van Schaik has reported that the consumption figures determined from enumerators' measurements of water carried from the tap are 40% lower than metered figures based on a study in Tambala village.(3) Similar enumerator "accuracy" estimates can be determined from recordings in 6 other 1981 village surveys. In each case, metered water use is compared to water use estimated by enumerators measuring the amount fetched from the tap. These figures are shown in Table 3. Generally the enumerators recorded less than the metered amount by 19 to 43%, but in 2 cases, the enumerators reported greater water use, by 5 and 9%, than what the meter showed. A certain amount of water is used for rinsing buckets and drinking or is spilled or wasted at the tap, and this is not measured by the enumerators. Human error is also involved in estimation (e.g. assuming a "20 litre" bucket holds 20 liters when it may hold 18 or 23 liters). Usually enumerator estimates will be less than the metered amount.

1.2 Daily Peak Factor

The previous tables have shown us that average village water use may range from as little as 5.6 lcd to as much as 34.5 lcd. Not only the average but variations in water consumption between households and from day to day should be considered when designing a supply. Some days a village may use much more than the average, and the water supply should be able to provide this within reason. The ratio of the peak day's use to the average use per day is the daily peak factor.

The book "Evaluation for Village Water Supply Planning" by Cairncross et al. (8) says that daily peak factors for larger villages will vary between 1.25 and 1.5, while smaller villages (less than a few hundred people) may have higher peaks due to high use by a few households. It is instructive to calculate daily peak factors for typical villages in the rural piped water program and this has been done for the 11 villages in the 1980-81 DLVW surveys and for the 2 seasonal surveys ('82-'83) of Chidothe village. Daily records for one week were available for the 11 villages and for 5 days for Chidothe. The method used is outlined on p. 61 of the mentioned book.(8)

The daily peak factors, shown in Table 4 and Figure 2, range from 1.30 to 1.84 with the smaller numbers usually associated with larger villages and the higher peak factors with smaller villages (as expected). Since the rural piped water taps are designed to serve a population of approximately 120 people, a design daily peak factor of 1.4-1.5 would probably be reasonable. Unless demand on the water supply is near capacity, however, it is likely that the current design prodecures allow sufficient flow at any one tap to handle peak demands.

TABLE 3

COMPARISON OF METER AND ENUMERATOR READINGS

PROJECT/TAP	TOTAL METERED USE, L	METERED DAY USE, L	ENUMERATOR REPORTED USE, L	ENUMERATOR USE / METERED USE
Nalipili/ Kangoma	9124	7656	8036	105%
Namitambo/ Chapweteka	11277	11277	6930	61%
Nalipili/ Misanjo	16095	156636	10018	64%
Mulanje West/ Nachimango	26976	25716	16115	63%
Nalipili/ Mangani	13810	13706	14912	109%
Chambe/ Nkawela	16330	16330	13157	81%
Nalipili/ Tambala	18601	18437	10596	57%

TABLE 4

DAILY PEAK FACTORS

PROJECT/TAP	SURVEY DATE	NUMBER HOUSEHOLDS	NUMBER PEOPLE	AVERAGE LCD	DAILY PEAK FACTOR
Nalipili Kangoma	10/81	22	93	11.61	1.55
Chagwa/ Chidothe	2/83	27	111	18.1	1.68
Chagwa/ Chidothe	8/82	26	113	20.3	1.62
Nalipili/ Misanje	12/80	33	120	10.8	1.36
Chambe/ Nkawela	6/81	34	135	17.0	1.84
Namitambo/ Chapweteka	5/80	38	158	6.1	1.40
Nalipili/ Tambala	1/81	52	184	8.7	1.32
Mulanje West/ Nachimango	1/81	50	219	10.7	1.37
Zomba East/ Mmamu	4/81	51	230	10.6	1.47
Nalipili/ Mangani	6/81	60	237	10.1	1.33
Zomba East/ Disi	6/81	64	241	13.8	1.39
Zomba East/ Mwangali	6/81	61	257	17.5	1.41
Zomba East/ Mitochi	5/81	94	387	9.7	1.30

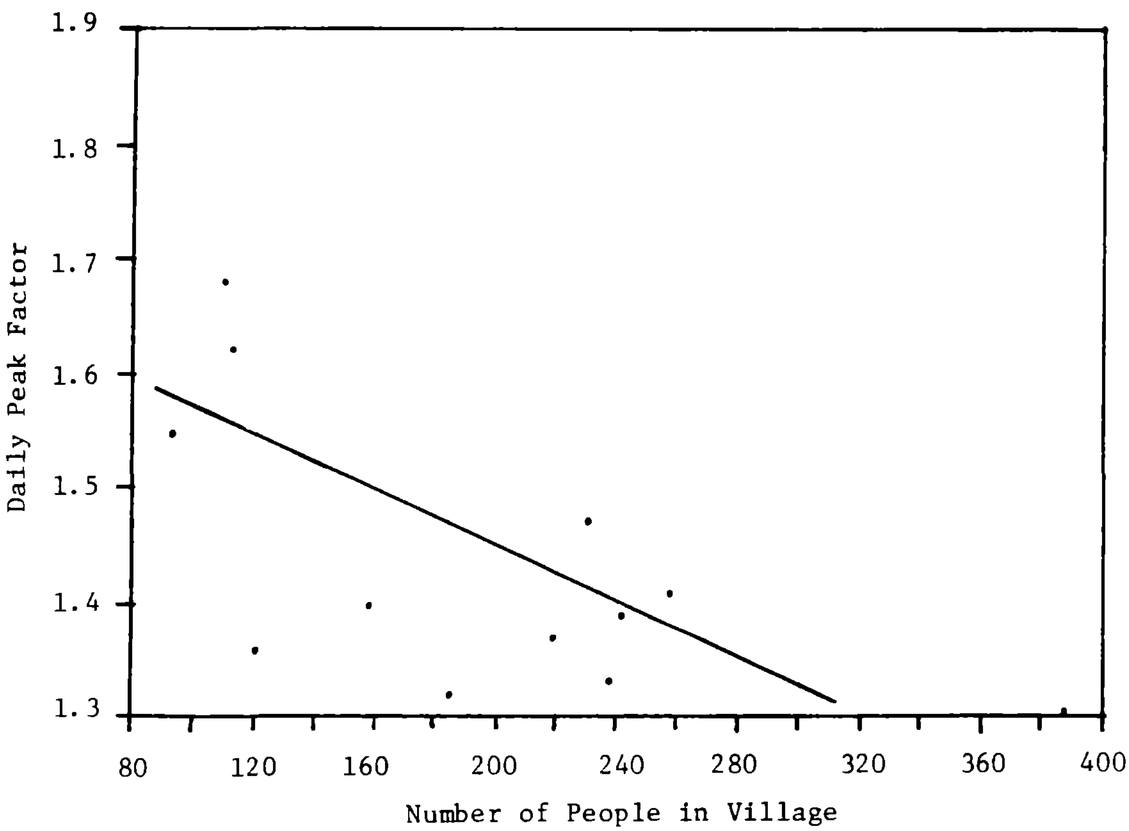

Figure 2. Daily Peak Factors as a Function of Village Size

The design for 36 lcd, when the population generally used less than 20 lcd, and for a flow of 1 gpm to all taps simultaneously, has thus far provided ample flow at most taps.

1.3 Reliability

The monitoring program of the rural piped water program is one of the many strengths of the program. The monitoring program is based upon the observation and repairs made by village tap committees, monitoring assistants and technical staff of the Water Department. All projects have monitoring assistants who periodically check all tanks, lines and taps and respond to breakage reports from the villagers. While boreholes and shallow wells often are in a state of disrepair due to inadequate monitoring and repair programs, the rural piped water program is generally quick to repair lines and minimize service interruptions.

Mr. A. Easton, Evaluation Officer of the Water Department recently published a thorough analysis of reliability of service in the Kawinga, Zomba East and Central Region projects (9) which reveals that these projects deliver water 90% of the time or better except in the few instances of major pipeline breaks. Nine projects were covered in the analysis and 7 of those delivered water at least 97% of the time during 1984. The one notable exception is the Zomba East project (where the epidemiologic study was conducted) which seems plagued by washouts of the Thondwe River crossings (1983 and 1985) and excessive pipeline breaks due to poor handling and installation of the pipes. Still, over 18 months in 1983 and 1984, it produced water 90% of the time or better as compared to the 80% performance in early 1983.

Most repairs (91%) were made within 2 days of being reported for the July-December 1984 period for all these projects. This supports the reliable service figures stated above. However, it is the major repairs, which affect more taps, that usually take the longest to repair. Thus the focus of reliability estimates should be on the number of taps affected in addition to the number of days to repair, as was done in Easton's report.

The reasons for breakages were attributed to the quality of the pipe, the field conditions, quality of laying pipes and unclassified "other" reasons. The greatest number of breaks, 34%, were attributed to the "quality of pipe" category which includes poor manufacture, deformation due to sun exposure, etc. This 34% figure was largely due to the high proportion of breaks in Zomba East. The quality of laying - bad joints, broken collars, too much solvent cement - was responsible for another 29% of the '83-'84 breakages. Twenty-three % of the breaks were due to the field conditions: accidental cutting by equipment, pipeline cracks due to shifting soil, vandals, etc. The "other" category received 14% of the breaks. So, over 60% of the breaks were caused by conditions of pipe quality, initial construction and installation, some of which might have been prevented with greater attention to the details and supervision of the work crews. As these problems appear and are attended to, the frequency of breaks has decreased. The analysis of number of breaks per kilometer of pipeline shows this declining trend in breakages as projects age.

The causes and frequency of breakages in these specific projects do not necessarily represent conditions in other rural piped water projects. The Mulanje area has problems with acid waters corroding and weakening asbestos cement pipe, and shifting soils causing pipe breaks. It is recommended that similar reliability and breakage analyses be conducted for Mulanje and other projects where the data are readily available.

1.4 Convenience

The rural piped water projects strive to have convenient placement of taps within villages. At the design stage, tap locations are roughly placed to serve populations within 1/4 mile or 400 meters. The final siting of the tap within the village is the decision of the community. Whether they are more convenient than the traditional sources depends on the hydrogeologic features of the area. Projects in wet areas may not be able to place taps more conveniently than the numerous wells, but in drier areas tap location can greatly improve accessibility to water. Two good examples are the Zomba East project and the Champira North project. The Zomba East project is sited in an area with shallow water tables and dambos. Water holes and streams are common and are often close to the houses. In the 1981 study by the Centre for Social Research, there was only a half minute increase in time to walk to the traditional water source over the tap, so there was no significant difference in distances. The 1985 health impact study in Zomba East showed average distances of 247 paces to traditional sources and 298 paces to taps, so the taps were slightly further away. This study was during the rainy season though, and dry season measurements would show longer distances to traditional sources as water becomes scarce.

The May 1985 survey of 336 households in Champira compared distances to taps and current clothes washing sources to those used prior to completion of the piped water project. Most women had changed their clothes washing habits from washing at the traditional source to washing at home using tap water. Thus the average distance to the tap was the distance to the source for wash water.

	Average, Meters
Distance to Tap	190
Distance to current source of wash water	190
Distance to previous source of drinking water	388
Distance to previous source of wash water	422

The Champira North project lies in the foothills of the Vipya and water sources are more scattered than in Zomba East. The taps are far more convenient than the traditional sources and women have all but abandoned their previous sources for both drinking and clothes washing.

The siting of taps is an important factor if water collection and use practices are to be altered. Most women understand and appreciate the benefits of piped water for drinking and cooking, but may choose a traditional source for clothes washing if it is more convenient.

2. WATER QUALITY IN THE RURAL PIPED WATER PROJECTS

The quality of water sources supplying the rural water projects is maximized by the initial choice of the source. Good engineering selection of the site, along with initial bacteriological and chemical tests to confirm good quality of the water source establish a sound base for continued good quality water. It is assumed, and correctly so as the following data show, that the bacteriological quality of piped water is far better than that of the traditional water sources. Information on the quality of water delivered at the taps is important for the operation and monitoring program, though, as it provides a sound basis for evaluating the performance of the system. Contamination can occur, and in a piped supply it has the potential for affecting far more people than a single well or borehole.

Water quality is usually tested by the enumeration of the bacterial indicators of pollution, total coliforms and fecal coliforms. Since coliform organisms derive from soil and vegetation as well as feces, their presence does not always indicate fecal contamination, however. Therefore, as is now routine in studies of water quality, the more specific test for fecal coliforms (FC) is given precedence in determining water quality. It should be recognized that the fecal coliform analysis does not distinguish between human and animal fecal contamination. Enumeration of fecal streptococci (FS) as a secondary indicator organism is often performed because this group has been used to test the quality of streams and lakes. Fecal streptococci are present in large numbers in human feces, though less numerous than the coliform group. For this evaluation, the FC results are used as the primary criteria for judging water quality and the FS results provide secondary supporting evidence.

The bacterial results are presented in summary form using geometric means, which result from taking the logarithm of each sample value, averaging the logs and raising 10 to that power ($10^{\text{average log}}$). A reason for presenting geometric means rather than the normal arithmetic means is that such a log transformation dampens the effect of a few isolated high counts. Bacterial counts are not usually normally distributed, but a logarithmic transformation "normalizes" the data and allows the application of statistical techniques such as analysis of variance.

The presence of indicator organisms means that pathogens could be present and thus that waterborne microbial infection could result. Another reason for using the log transformation relates to the relationship between dose of a pathogen and probability of infection, the "dose-response" relationship. This relationship is generally of a log-linear form. Using a linear scale implies that a dose of 200 organisms is "twice as dangerous" as a dose of 100 organisms. A log-linear dose-response implies that 1000 organisms are "twice as dangerous" as 100 organisms. Thus logarithmic differences more appropriately represent the differences of concern in human health issues.

The Central Water Laboratory in Lilongwe has sampled rural piped water supplies sporadically but increasingly in the past few years as the Water Laboratory facilities have improved and expanded. During the period July, 1985-January, 1986, 6 USAID funded rural water projects will have water quality tested in both dry and wet seasons. Water quality results which are currently available from the Central Water laboratory are from intake and tap samples conducted in 1984. Rural water projects in the Ntcheu, Dedza, Zomba, Mangochi, Kasupe, Machinga and Mulanje districts were sampled in the dry season and in the Ntcheu district in the wet season of 1984. Rural water taps had an average FC count of 15 colonies/100 ml and intakes had an average of 21 FC/100 ml. Samples collected in the wet season had higher FC colony counts than the samples collected during the dry season.

Although higher bacterial counts in the warm, rainy season are not surprising, these values should not be considered typical since they represent only a few samples from one project. The results of the 1985-86 sampling of 6 rural water projects should be more indicative of overall water quality in the piped water systems.

Other information currently available on bacteriological water quality in piped systems comes from data collected in the course of the health impact study in Zomba East project during January-May 1985.[1] One hundred seven samples were collected at taps in the southern part of Zomba East, 166 samples were taken from boreholes, rivers and unprotected wells, and another 271 were collected from drinking water containers in households using these sources. Comparisons of the quality changes between source and home have been made. For this presentation, the information has been grouped as follows in Tables 5 and 6:

Tap - samples taken from unsterilized taps
Borehole - samples taken from boreholes and lined or backfilled wells with handpumps
Unprotected - samples from unprotected wells and rivers

The fecal coliform (FC) and fecal streptococci (FS) levels, shown in Tables 5 and 6, were significantly lower in the samples from taps and houses using taps than the levels in other sources of water. Fifty percent of the samples from taps and houses using taps had an FC count of 10 or less colonies/100 ml. The geometric mean FC count showed no noticeable deterioration from tap to house, being 12 colonies/100 ml at the tap and 16 at the house.

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[1] NOTE: Normally one would choose a random sample of households. This sample is definitely not random but is heavily weighted towards children who develop diarrhea and other illnesses. If diarrhea is indeed associated with poor water quality then the average quality from this analysis would be greater than the average quality from a random sample. This would hold for both improved and unimproved sources and therefore the relative comparisons are still justified.

Table 5

Fecal Coliform Means
Colonies/100 ml

Sample Location		Number Samples	Mean,* Col/100 ml
Piped Water:	Source	107	12
	House	104	16
Borehole:	Source	20	46
	House	20	240
Unprotected Wells & River:	Source	146	540
	House	147	760

* Geometric Mean

Table 6

Fecal Streptococci Means
Colonies/100 ml

Sample Location		Number Samples	Mean,* Col/100 ml
Piped Water:	Source	100	280
	House	94	1100
Borehole:	Source	20	770
	House	20	2740
Unprotected Wells & River:	Source	141	3900
	House	142	4780

*Geometric Mean

Borehole water quality was slightly worse than that of piped water with a mean FC of 46 colonies/100 ml at the source and 240 in the home. This difference between source and home is not significant. It should be noted that the quality of water from these old boreholes is much worse than that found in the newer project boreholes which typically deliver water with less than 10 fecal coliforms and 20 FS per 100 ml.(10)

The unprotected sources had variable quality, but it was substantially poorer than either the taps or boreholes. Fourteen percent of the samples had no FC, yet the other 84% had counts over 100/100 ml. The distribution in the households followed a similar pattern, and overall the average quality between source and house changed little considering the high counts found in the source. The average quality was 540 FC colonies/100 ml at the source and 760 FC colonies/100 ml in the home. The quality in unprotected sources and boreholes improved as the heavy rains subsided, explaining some of the lower values. [Thus in the peak bacterial diarrhea season (rainy) the difference in water quality between protected and unprotected sources is greater than other times.]

Fecal Streptococci values were at least an order of magnitude higher than the counterpart fecal coliform values for source and house samples. This agrees with findings of the Central Water Laboratory. (10) Their studies have shown that FS are more predominant than FC organisms irrespective of season or water source type.

Perhaps the most striking conclusion drawn from these results is the overall good water quality (as measured with FC) found in homes using tap water. The water collection and storage habits were investigated to see if the tap users had better hygiene practices than the other population. The habits were similar in all the groups. Almost all women stored their water inside the house. The covering and fetching habits varied but there was no relationship between these practices and water sources. An analysis of variance was performed to assess the effect on household water quality (FC logarithmic values) of: quality at water source, where jar stored, whether jar covered, whether dipping cup had handle and whether the same or different jar was used for fetching and storing the water. The only significant association with household water quality was the source of the water. Since there is little variation in collection and storage practices, little association with changes in water quality can be expected. The population in this area generally ascribes to those practices which are promoted to reduce water contamination. From these results these practices seem to be successful. Thus when comparing different water sources in the Zomba East area, we see that the water source quality is the main determinant of the quality of water that the people will actually by drinking.

3. WATER USE AND SANITATION SURVEY OF CHAMPIRA NORTH RURAL PIPED WATER PROJECT

A water use and sanitation survey in the Champira North Rural Piped Water Project was conducted in May, 1985. This is a summary of the second report issued on the survey. The first, "Water Collection and Use Survey of Champira North Piped Rural Water Project," was issued by A. Easton, Evaluation Officer of the Water Department, Government of Malawi on July 1, 1985. The second report is presented in its entirety in Appendix A.

Most of the residents of this area are subsistence farmers with low socio-economic status and little education (< Standard 5). The 17 villages surveyed (351 households) were quite similar except for Champira Trading Center, whose residents were businessmen and government workers with greater wealth and education.

Fifty percent of the population had latrines and of those, 83% were judged to be in good condition. Another 18% of the population had had a latrine before the rainy season but it had collapsed prior to this survey. The factors which were most strongly correlated with the ownership of latrines are a large household size, increased wealth as seen in the number of possessions and quality of house construction and the occupation of the household head in business or government. The mother's education also had a positive association with latrine ownership, but this association was weaker and less significant than those other variables. The probability of a latrine being well constructed and maintained was positively correlated to the household size and number of possessions owned.

The rural piped water project has provided standposts an average 190 meters from the dwellings of those whose use the tap water. Although fourteen of the 351 houses surveyed chose not to use the standposts because of the distance (> 850 meters), the majority of those surveyed (79%) were closer to the standposts than their traditional water source and another 17% chose to use tap water even though it was further than their previous water source. In general, the standposts were an average 229 meters closer than the previous water source, meaning the people walked less than half the former distance and cut their water-fetching time in half.

Prior to the piped water project, these people got their drinking water from unprotected wells (70%), boreholes (20%), rivers (9%) and protected wells (1%). The women had washed their clothes at the river (39%), at unprotected wells (20%), at home (39%) and elsewhere(2%). Now, however, 97% of the women using tap water for drinking also use it for clothes washing at their homes year-round. Again there is a time savings in fetching clothes-washing water, since previously they walked an average 422 meters compared to 190 meters now.

The pattern of water usage is encouraging since most people use tap water for their major water consuming activities: clothes washing, bathing, cooking and washing food and utensils. With the exception of men and children bathing, 94% or more of the households use tap water for these activities. Eighty-one percent of the households fetch water for bathing of men, 85% for bathing children and 99% for bathing women. This is significant in that the provision of the standposts may have completely eliminated or certainly minimized contact with the traditional water sources for many people in this area. Health effects would be anticipated due to reduced exposure to waterborne and water contact diseases, since a much better quality water is used now and contact with traditional sources is minimized.

The average amount of tap water used is 20 liters per capita per day, compared to 16 lcd for those who still use traditional sources. This difference can be accounted for by the lower economic status of the non-tap users, their patterns of clothes washing away from home, and possibly the increased distance to their sources. For those who use tap water, the variables which showed significant association with consumption (lcd) were wealth, household size and the percent of household members who are adults. Statistical analyses indicated that, as had been expected on the basis of behavioural theory and data from other studies, consumption increased as:

1. Wealth increased and household size and percent of household who were adults decreased, and

2. Distance to tap decreased and mothers education increased.

For the data set analyzed, we can state with confidence that the effects of the first set of factors are true effects. For the second set of factors it is possible that the relationships would not be sustained if more data were available.

4. HEALTH IMPACT EVALUATION: CASE-CONTROL STUDY

An epidemiologic case-control study was conducted in the Zomba district to assess the health impact of the rural piped water supply on diarrhea incidence in young children. The study is reported in detail in Appendix B of this report. Essentially, it was a study of water-borne, as opposed to water washed, diarrheas (11) since the bacteriologic water quality of the piped water supplies was significantly better than that of the alternative sources. Neither this study nor previous studies in Zomba East have found the quantity of water used in the rainy season to increase with piped supplies, since alternative water sources are abundant and accessible in this part of Malawi.

The diarrheal diseases were chosen for study because of their potential transmission through water supplies and their public health significance for children. In Malawi, diarrhea is the third highest cause of clinic-reported illness and fifth highest cause of hospital-reported deaths in children under 5 years of age. (12) The eastern part of the Zomba district was selected as the project site because a rural piped water supply has been successfully functioning in part of that area for years. The case-control study allowed the comparison of children reporting to health clinics with diarrhea (the cases) to children reporting with non-water-related illnesses (the controls) on the basis of water supplies, sanitation and other environmental and socio-economic conditions. A detailed description of methods and results is presented in Appendix B.

Eight hundred and forty children were recruited for the study over a four month period, January-May, 1985, at one government and two mission clinics. Interviews were conducted with the mothers of the children both at the clinic and in their homes. During home interviews, water samples were taken from drinking water containers and the corresponding water sources for a random sample of 264 homes. The results of the water quality analyses are presented in Section 3 of this report.

Fecal samples were collected at the clinic from a subsample of 89 children, both cases and controls, for laboratory identification of diarrheal pathogens. Parasites and viruses in the stools were more common for diarrhea cases than controls. The similarity of bacterial isolation rates for cases and controls is indicative of the asymptomatic presence of intestinal pathogens in the control. The differences in pathogen isolation rates between diarrhea cases and controls were not found to be significant. This may be more a function of small sample size than actual similarity, however.

The epidemiologic analysis revealed that the risks of diarrhea associated with the use of piped water were minimized when other environmental improvements had been made. For the majority of the children in this study who were not exclusively breastfed, the combined improvements of having piped water and a latrine were associated with a diarrhea risk 2-4 times less than that diarrhea risk associated with a solitary improvement in water or sanitation. For those children who had the additional benefit of being exclusively breastfed, thus having little bacterial contamination of food, the combined effect of piped water, latrines and breastfeeding reduced the risk of diarrhea 3-8 times the amount than when only piped water or latrines were available in the families of those breastfed children. When piped water or latrines were available, but as a solitary health intervention, no reduction in the risk of diarrhea was observed compared to the risk for those children with traditional water sources and no latrine.

These findings demonstrate the theory that the pathogen dose-disease response relationship is not linear.(13) A major reduction in pathogen exposure, e.g. in water supply, may not produce a major or even measurable reduction in disease incidence due to the remaining level of pathogen exposure via other routes such as poor hygiene and food contamination. Thus, health impacts of water supplies should not be judged in isolation, but to the degree which they affect health impacts when other environmental improvements are provided either simultaneously or subsequently.

The results of this study are specific to the population in the eastern part of the Zomba district who use the health clinics during the months January-May. In that there may be some characteristic differences between clinic users and the general population, such as a higher socio-economic status or greater health awareness, these results cannot be casually applied to the population at large. With the understanding that the basic disease process will be affected by sequential or simultaneous health interventions regardless of the person however, the heightened effects of a combined water, sanitation, health education program can be assumed. The reduction in risks of diarrhea for young children in general may be somewhat less than those found in the case-control study. The children studied may be more receptive to environmental improvements due to the mother's or family's overall attention to health. Also, since the timing of the study coincided with the yearly peak of diarrheas in children 0-4 years during the rainy season, an annual impact on diarrhea incidence would not be projected at the same levels. Notwithstanding, the transmission routes of poor water, food and sanitation do have a clear association with clinically diagnosed diarrheas during those critical months of diarrheal morbidity.

The need for health intervention programs which couple improved environmental services and hygiene is obvious. An isolated intervention may not be accompanied by the meaningful health improvements which are so often assumed. For diarrheal diseases which are of great consequence in both child morbidity and mortality, pathogen exposure is the result of many sources. As shown in this study, a coordinated program which addresses the major fecal-oral transmission routes - poor water, food and personal hygiene - has the greatest potential for measurable success in improving the health of these vulnerable young children. The decision by the Government of Malawi to couple water supply programs with health education and sanitation programs is clearly a wise choice and should be strongly encouraged.

5. HEALTH IMPACT EVALUATION: EXISTING REPORTS

The intent of the additional health impact evaluations was to examine existing health reports or available data bases in Malawi for evidence of water supply impacts on health. One such reported incident was the Mulanje cholera outbreak in 1973 which was seemingly less severe in areas served by piped water.(14) Plans had been made to analyze Mulanje district hospital and clinic records to compare cholera incidence in areas with and without rural piped water. Unfortunately, the decade-old records could not be located and this plan was abandoned.

Another report was located in Malawi which does document health impacts of water on a water-washed disease, trachoma. The Lower Shire Valley Ocular Disease Survey was conducted in 1983 to provide data on blindness and ocular disease incidence and to determine nutritional, infectious and other environmental risk factors associated with eye diseases.(15) Inflammatory trachoma was found to be of critical public health significance with total trachoma prevalence highest (40%) among children under 6 years of age. Of all the determinants of risk for trachoma examined - social, hygiene and geographic - the most important was the distance of the village from the river. Moderate to severe inflammatory trachoma increased significantly as one went further away from the river. This is thought to indicate a decreased use of water for washing, although no specifics were given in this preliminary analysis. The Shire data also indicated a consistent trend towards lower trachoma prevalence rates among those children who wash their faces more often. Other potential transmission conditions such as household crowding and nose-blowing techniques showed no association with trachoma prevalence.

Although this survey was not specific to rural piped water projects or any other water supply, the results can be considered with respect to the implications for a water supply which improves accessibility to and increases availability of water. The Champira survey has already shown a slight increase in water consumption with decreasing distance to the taps. If a piped water system supplied water taps considerably closer than previous water sources, water usage would probably increase, including water used for bathing. Currently, one of the USAID funded rural piped water projects, the Mwanza project, is being built near the lower Shire valley. This region also has the hot, dry climatic conditions which are conducive to trachoma transmission. In areas such as the lower Shire valley where trachoma is endemic, improved water supplies could have measurable impact on lowering trachoma incidence.

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APPENDIX A

WATER USE AND SANITATION SURVEY OF CHAMPIRA NORTH RURAL PIPED WATER PROJECT

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1. INTRODUCTION

The present report is provided as a supplement to the initial report "Water Collection and Use Survey of Champira North Piped Rural Water Project" by A. Easton, Water Department, Ministry of Works, July 1, 1985. Constraints on time and resources during the initial analysis precluded the thorough analysis of the survey data that had been planned. Additional investigations of the data have occured since that time and those results and supporting information for the initial results are presented. [In several cases, slightly different results from the initial report are presented here due to recent corrections made in the data set. In those instances, results presented in this report should be considered the correct ones.]

1.1 Definition of Variables

Several variables have been created to facilitate the statistical analysis and presentation of the Champira data. Each variable listed below was formed from information provided in the questionnaires. When one of these variables is referenced in the text, it will be specified in capital letters:

ADULTS - number of household occupants age 15 or older.

BUILDING MATERIALS - household construction items which imply higher socio-economic status. Four possibilities: cement floor, fired brick, iron sheets and glass windows. Each of these items is assigned a value of one. A house can have between 0 and 4 building materials.

POSSESSIONS - number of key consumer items owned by a family. Each item is assigned a value of one, with a possible total of 9. The items surveyed were locally made chairs, locally make table, manufactured chairs, manufactured table, radio, clock or wristwatch, lamp, bicycle and sewing machine.

WEALTH - the sum of BUILDING MATERIALS and POSSESSIONS.

OTHER occupations - Any head of household's occupation not specified in the questionnaire. Those specified were subsistence farmer, commercial farmer, businessmen, teacher, labourer, carpenter, fisherman and builder. Other occupations were usually government positions such as postal worker, water assistant, policeman, agricultural advisor, etc.

LCD -liters of water consumed per capita per day. This value is computed by dividing a household's volume of water collected daily by the number of household members. [The information on this page has been briefly summarized from Easton's report for general introduction to the analysis.]

1.2 Methodology

The population of the Champira North Rural Piped Water Project was surveyed by a two-stage random sampling process of 351 households. In the first sampling stage, 12 village groups (each with at least 200-300 people) were selected using probability proportional to size (pps) selection from the total group of about 11,000 people. Once a village group had been selected, then 30 households were randomly chosen from that village or group or group of villages. The use of pps selection and two-stage sampling ensured an equal opportunity of selection for all households in the project area.

Questionnaires were administered to the female head of household by one of 3 enumerators, all HESP personnel from that general area. One week of training had been held prior to the two weeks of the survey, and field pretesting of the questionnaire was conducted during that week also.

1.3 Background

The Champira North Rural Water Project is a recently completed (1983) USAID-funded project in the Northern Region. It covers an area of 400 square kilometers and presently serves about 11,000 people with 156 taps. The project is designed to provide water for 24,000 people.

1.4 Demographic Aspects

Champira project is located in an area of the Ngoni and Tumbuka tribes. Eighty-two percent of the households heads are subsistence farmers, 4% businessmen, 4% builders and 10% held OTHER jobs. The average household size is 4.5 persons, with most families having between 2 and 7 persons.

The mother's level of education is fairly evenly distributed between the three categories none, Standard 1-4, and Standard 5 and above. Most of the families (81%) had no BUILDING MATERIALS and POSSESSIONS were limited to 2 or less for 69% of the households.

2. DEMOGRAPHIC STRUCTURE OF POPULATION

2.1 Head of Household

The head female was interviewed in each household. Sixteen percent were the sole head of household, 81% were the wives of the head of household, 3% were daughters of the head of household and 1% were related in some other way.

2.2 Variations Among Villages

This study was designed with random sampling so the data would represent the entire Champira North project population. There was little variation in demographic structure from village to village with the one notable exception of Champira Trading Center. Of the 26 households interviewed in this village, 11 (42%) of the household heads were businessmen and 13 (50%) held OTHER occupations. The other villages were composed mainly of subsistence farmers. Table 2.1 shows demographic differences between Champira T. C. and the other villages. These differences have an effect on water and latrine use, as will be discussed later.

TABLE 2.1 DIFFERENCES BETWEEN CHAMPIRA T.C. & OTHER VILLAGES

Household Averages	Champira Trading Center	Other Villages
Household consumption, liters/day	148	76
LCD	29.5	19.2
POSSESSIONS	3.6	1.6
BUILDING MATERIALS	2.1	0.2
Household size	5.5	4.5
number of adults	2.6	2.4

2.3 Relationships Between Demographic Characteristics

It is helpful to be aware of interrelationships between demographic characteristics as the water use and sanitation data are examined. The variables do not always exert independent influences on water and sanitation since they may be correlated to one another. These relationships between occupation, mother's education, WEALTH, household size and ADULTS are as follows:

Occupation and mother's education - For subsistence farmers, 30% of the mothers have education beyond Standard 4. But for businessmen and those with OTHER occupations, this percentage is almost 60%.

Occupation and WEALTH - Subsistence farmers have an average WEALTH of 1.6 whereas all other occupations have an average 4.2 WEALTH index.

Occupation and household size - Businessmen and OTHER occupations have an average household size of 5.1 people whereas subsistence farmers have an average size of 4.6 people.

Mother's education and WEALTH - Household wealth tends to increase when the mother is educated beyond Standard 4.

Mother's education and household size - Household size increases slightly as the mother's education increases.

WEALTH and household size - WEALTH increases as household size increases and as the number of ADULTS increases.

3. LATRINES

One of the objectives of the study was to assess the status of latrine ownership and evaluate the "quality" of latrines. The quality can be considered a surrogate for use since a poorly constructed and maintained latrine is less likely to be used than a well maintained latrine. Quality was judged by the Health Assistants, who are trained for such evaluation, based on general construction techniques, depth of pit, cleanliness, etc. Since many latrines collapse during the rainy season and this survey was conducted at the end of the rainy season, we also obtained information on how many households had latrines before the rainy season. These people are more likely to rebuild latrines than those who never have had one. The effect of the HESP program was not evaluated per se, since we did not have baseline data on latrine use before the HESP project.

The distribution of latrines and latrine quality among all 351 households surveyed is as follows:

- 32% have no latrine and did not have one before the rainy season
- 18% have no latrine,but did have one before the rainy season
- 8% have a latrine, but in poor condition
- 32% have a latrine in good condition, but without a cover
- 11% have a latrine in good condition and with a cover

Thus 50% of the population had latrines in May and 68% had latrines before the rainy season. Eighty-three percent of the existing latrines were in good condition.

The association between latrine ownership and other independent variables, e.g. family size, occupation, etc., was determined with a logistic regression model. This model gives the probability of having a latrine (between 0 and 1) based upon conditions in the household. Table 3.1 presents the variables used to model the probability of having a latrine, the estimated coefficients and their statistical significance. The variables included in the model were those thought to be correlated to latrine ownership: size of household, mother's education, occupation of head of household, quality of house in building materials and number of 9 specific possessions owned by the family. All of these variables showed a positive correlation with the probability of latrine ownership. The probability of having a latrine increased with the household size, mother's education, increasing economic status of occupation and the number of special building materials and possessions. These increases in the probability of having a latrine associated with changes in the variables are given in Table 3.2.

Certain variables were more strongly associated with latrine ownership than others, however. An increasing number of possessions, building materials and household size, and occupation as businessman or OTHER produced the greatest effect on increased likelihood of having a latrine. This is reflected in the size of the coefficient and the range of values for those variables. The coefficients for possessions and household size were also highly significant ($p<0.01$) indicating that

TABLE 3.1

LOGISTIC REGRESSION MODEL FOR PROBABILITY OF HAVING A LATRINE

Variable	Coefficient	p
intercept	-1.769	0.000
Household size HHS = 1-11	0.179	0.004
Mother's Education EDUC = 0 if no education = 1 if Std. 1-4 = 2 if >Std. 4	0.152	0.318
Building Materials BMAT = 0-4	0.584	0.052
Possessions POSS = 0-8	0.405	0.000
Occupation WORK = 1 if businessman, OTHER = 0 if anything else	0.814	0.135

$$\text{Probability of Having Latrine} = P = \frac{1}{1 + \exp^{-y}}$$

where $y = -1.769 + 0.179\,(HHS) + 0.152\,(EDUC) + 0.584\,(BMAT) + 0.405\,(POSS) + 0.814\,(WORK)$

TABLE 3.2

CHANGES IN PROBABILITY, P, OF HAVING A LATRINE BASED UPON CHANGES IN OTHER VARIABLES

Household Size[1] =	3	5	7	9	11
P =	0.23	0.29	0.37	0.46	0.55

Mother's Education[2] =	None	Std. 1-4	>Std. 4
P =	0.29	0.33	0.36

Building Materials[2] =	0	1	2	3	4
P =	0.29	0.44	0.57	0.71	0.81
Possessions[2] =	0	2	4	6	8
P =	0.29	0.48	0.68	0.83	0.91

Occupation[2] =	Farmer, etc.	Businessman, OTHER
P =	0.29	0.49

[1]Where all other variables = 0

[2]Where household size = 5, all other variables = 0

their association with latrine ownership can be viewed with confidence. The mother's education had the least effect on the probability of having a latrine and was also the least significant statistically.

Another model was developed to assess the association between having a good quality latrine (one in good condition with a cover for the hole) and household variables. The results of the logistic regression model are presented in Table 3.3. Again, the household size and number of possessions were most strongly related to the likelihood of having a latrine in good condition. As can be seen in Table 3.4, the other variables had little or no association with the probability of the latrine being in good condition with a cover.

These associations revealed here are useful in that they can give guidance to introduction of latrine projects and targeting families that need incentives to build a latrine. The families which are larger or have greater wealth will be more receptive to building latrines, according to these observations. Conversely, smaller or poorer families may need special attention and encouragement from the HESP assistants to build latrines and maintain them.

Table 3.3

Logistic Regression Model for Probability of Having a Good Latrine with a Cover[1]

Variable	Coefficient	p	Range of Variable
Intercept	-2.838	0.000	-
Household Size (HHS)	0.237	0.015	1-11
Mother's Education (EDUC)	-0.097	0.682	0-2
Building Materials (BMAT)	-0.006	0.978	0-4
Possessions (POSS)	0.119	0.285	0-8
Occupation (WORK)	0.200	0.740	0-1

$$\text{Probability of Having A Good Latrine with Cover} = P = \frac{1}{1 + \exp^{-y}}$$

where $y = -2.838 + 0.237\ (\mathrm{HHS}) - 0.097\ (\mathrm{EDUC}) - 0.006\ (\mathrm{BMAT}) + 0.119\ (\mathrm{POSS}) + 0.200\ (\mathrm{WORK})$

[1] Based upon all families who had a latrine

Table 3.4

Changes in Probability, P, of Having a Good Latrine with Cover Based Upon Changes in Other Variables

Household Size[1] =	3	5	7	9	11
P =	0.11	0.16	0.24	0.33	0.44
Mother's Education[2] =	None		Std. 1-4	>Std. 4	
P =	0.16		0.15	0.14	
Building Materials[2] =	0	1	2	3	4
P =	0.16	0.16	0.16	0.16	0.16
Possessions[2] =	0	2	4	6	8
P =	0.16	0.20	0.24	0.28	0.33
Occupation[2] =	Farmer ,etc.		Businessman		
P =	0.16		0.19		

[1]When all other variables = 0

[2]When Household Size = 5, all other conditions = 0

4. WATER COLLECTION AND WATER USE

4.1 Distance to Drinking Water Source

The new tap system provides taps an average of 190 meters from the dwelling of those who use the taps and an average of 229 meters closer than their previous drinking source. However, some 60 people chose to use tap water even though it was further than their traditional water source. Of all interviewed who lived between 0 and 355 meters (500 paces) further from the tap than from their traditional source, 97% used the tap. Taps are generally sited to serve a population within a 400 meter radius and 90% of those surveyed who live within 400 meters of a tap use it.

Before the taps were installed, the distribution of sources of drinking water (for those now using the tap) and average distances to those sources were as shown in Table 4.1.

TABLE 4.1 PREVIOUS DRINKING WATER SOURCES

Source	% Drawing from this Source	Average One-Way Distance Meters(paces)
Borehole	20%	316 (445)
River	9%	479 (675)
Unprotected well	70%	400 (563)
Protected well	1%	290 (408)

** note: 1 pace = 0.71 meter

The 70% who were drawing from an unprotected well now draw from a much better source, to which they are an average of 213 meters closer.

4.2 Distance to Clothes Washing Source

Traditionally the women in this area had washed their clothes either at the river (39%), at home (39%), at an unprotected well (20%) or elsewhere (2%). The average walking distance to the water was 422 meters, one way. Since the taps have been installed, however, 97% of the women who use tap water for drinking, also use it for clothes washing at their homes. They now walk only an average 190 meters to fetch their clothes washing water. These clothes washing habits are consistent year-round, as well, since only 2% of the women vary their washing places seasonally. The impact of washing slabs could not be evaluated based on the data that were available.

4.3 Water Consumption

The average water consumption, in liters per capita per day, was 19.9 LCD for those using the tap and 15.5 for those 14 households who chose other water sources. This difference is not necessarily caused by a preference for tap water, however. The non-tap users were less wealthy and only half of them brought water to their homes for clothes washing. These factors could easily account for the difference in water consumption.

The figures above were calculated by averaging the individual LCD figures for each household. Another method of computing LCD is to divide the total volume of water fetched daily by the number of people surveyed. This yields a smaller number, usually, which does not reflect household variability, but is consistent with design use of individual consumption, LCD. The corresponding figures calculated this way are 17.8 LCD for tap users and 13.5 LCD for non-tap users.

4.3.1 Water Consumption: Association with Other Variables

Many factors can affect water consumption, such as the household size, distance to the water source, wealth, and mother's education. Correlations were developed between individual consumption, LCD, and those variables shown in Table 4.2 to see which had a strong association. (All variables were treated as continuous variables. Each was initially examined individually without correcting for the relationships among independent variables.) Household size and the percent of household members who were adults were significantly associated with the LCD; so were the two wealth indices, BUILDING MATERIALS and POSSESSIONS. Neither mother's level of education or the distance to the tap showed a significant association with LCD. This may be due to the lack of variability in these factors over the range of LCD. Two-thirds of the mothers had education less than Standard 5 and two-thirds lived with 210 meters of the tap.

Consumption also varies with occupation, with the "wealthier" occupations having a higher water consumption. Subsistence farmers had an average 18.9 LCD while businessmen and OTHERs had an average 26.3 LCD consumption. For Champira Trading Center the concentration of businessmen and government workers resulted in an average LCD of 29.5 This distinction is important to note when designing water service for more developed villages in a rural water project.

TABLE 4.2 CORRELATIONS BETWEEN CONSUMPTION AND VARIABLES

Variable	r^2	P-value	Does LCD increase or decrease with this variable?
household size	0.17	<0.0001	decrease
percent of household members who are adults	0.13	<0.0001	decrease
BUILDING MATERIALS	0.07	<0.0001	increase
POSSESSIONS	0.06	<0.0001	increase
mother's education	0.005	0.17	increase
distance to tap	0.004	0.18	decrease

A regression equation was developed to fit the model of water consumption, the dependent variable, as a function of those factors we would expect to affect consumption: household size, wealth, distance to tap and mother's education. [Occupation was not used in this model since it is a categorical variable and is reflected in wealth.]

The resulting equation is:

$$LCD = 30.3 - 2.98HHS + 3.18BM + 1.53POSS - 0.005DIST + 0.83EDUC$$

where
HHS = household size
BM = number of BUILDING MATERIALS
POSS = number of possessions
DIST = distance to tap in paces
EDUC = mother's education level: 0=none
1=Std. 1-4
2=>Std. 4

[$r^2 = 0.34$; all coefficients highly significant, $p<0.0001$, except for distance, $p=0.11$ and education, $p=0.21$]

Thus a typical family with distance=269 paces, household size=5, BUILDING MATERIALS=0, POSSESSIONS=2 and education=1 would have an LCD=17.9, quite close to the observed average of 18.9 LCD for families of subsistence farmers. The value of such an equation lies not in its predictive ability, however, but in the quantification of the importance of the different variables. The size of the coefficients, coupled with the typical ranges in values of the variables, reveals which factors affect consumption the most, as shown in Table 4.3. Household size has by far the greatest effect, followed by possessions, building materials, distance and lastly education, for those levels most commonly found in this area.

Table 4.3 EFFECT ON CONSUMPTION FROM FACTOR CHANGES

Variable	Range of Values for 80% of Population	Effect on Consumption, LCD
Distance	100-600 paces	Reduced by 0.5 for increase of 100 paces(71 meters)
Household size	3-6 people	Reduced by 3 for 1 person increase in household size
BUILDING MATERIALS	0-1	Increased by 3.2 for increase of 1 building material
POSSESSIONS	0-3	Increased by 1.5 for increase of one item
Education	0-1	Increased by 0.8 for for 1 level increase in mother's education

Appendix B

HEALTH IMPACT EVALUATION OF THE MALAWI RURAL PIPED WATER SUPPLY: A CASE-CONTROL STUDY OF DIARRHEA

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INTRODUCTION

The USAID project "Malawi Self-Help Rural Water Supply" aims to improve the basic living conditions and health of Malawi's rural population by providing clean and accessible water supplies and promoting health education and sanitation. The project also seeks to strengthen the rural piped water program by supporting applied research in monitoring and evaluation of the program. The present health impact evaluation was undertaken to provide a measure of the reduction of water-related diseases among rural villagers and to provide feedback to the health and water programs on community responses and needs.

The Malawi gravity-fed rural piped water program is an excellent setting for a health impact evaluation because of its well established success in providing water. The program dates back to 1968 and is based upon self-help community development principles. Projects are village initiated, installed and maintained and have a history of reliable performance and utilization.

The diarrheal diseases of young children were chosen for study because of their public health significance. Diarrhea is an endemic problem in Malawi, being the third highest cause of clinic-reported illness and fifth highest cause of hospital-reported deaths in children under five years of age (Ministry of Health, 1984). The evaluation was directed at children under 5 seeking clinical treatment for diarrhea. The peak diarrhea season in Malawi occurs during the warm, rainy season November-March, and is associated with the proliferation of bacterial pathogens under these conditions. Since bacterial pathogens are considered to be more responsive than viral pathogens to water and sanitation improvements, the study was conducted during the rainy season to maximize the chance of showing a significant health impact.

The methodology chosen for the health impact evaluation was an epidemiologic case-control study because it is relatively inexpensive and rapid compared to long term prospective studies. Over the past two years much international attention has been directed towards developing guidelines for cost-effective case-control studies on water and sanitation (World Health Organization, 1985). The application of this methodology to the rural water and sanitation program in Malawi was a pioneering effort. The results serve the scientific community at large as well as the Water Department and Ministry of Health of the Government of Malawi.

This report presents the methods and results of the case-control study of the association between childhood diarrhea and water and sanitation improvements. The implications for future health interventions are addressed.

METHODS

Study Population

The eastern portion of the Zomba district was chosen as the study site because of the 4 year old rural piped water project in much of the area and the support facilities and services available in the town of Zomba. The site was selected by officials of the Water Department and the Ministry of Health. Specifically, the rural study area was southeast of Zomba town, encompassing much of the Traditional Areas (T.A.) Mwambo and Chikowi and the southern portion of T.A. Kuntumanji. Children under five years of age brought to one of three health clinics - Pirimiti Mission Clinic, Chamba Government Dispensary and Sitima Mission Mobile clinic - were the subjects of investigation. Pirimiti Clinic was the primary recruitment site (67% of the participants) since its location on the boundary of the piped water project made the service area include populations with and without piped water. Chamba and Sitima Clinics were used for additional subject selection since the diarrhea reporting rate at Pirimiti was not high enough to yield the desired 450 diarrhea cases in 4 months.

Recruitment of the cases and controls took place during the period 7 January to 6 May, 1985; 6 days a week at Pirimiti, as frequently as possible at Chamba after week 5 and 2 days/week at Sitima for weeks 2-5. All children reporting with severe diarrhea, or mild diarrhea and no other symptoms were selected as cases, if the mother agreed to participate. Severe diarrhea was diagnosed by the project nurse. A child with dehydration and watery diarrhea (4 or more loose stools in the last day) or blood and mucous in the stool with fever was deemed to have severe diarrhea. Controls were randomly selected from children with symptoms of malaria, respiratory illness, whooping cough, measles and chickenpox who did not have severe diarrhea. The number of controls recruited at each clinic was approximately equal to the number of cases recruited at that clinic.

Project Team

The research team was composed of 9 Malawians and two expatriates. The research supervisor was a graduate student from the University of North Carolina (UNC) who coordinated all the field work. Technical direction and assistance was provided by a faculty member of UNC. The field supervisor coordinated the enumerators' activities and management of the questionnaires. The Ministry of Health assigned a nurse to the project to handle clinic diagnostics and interface with health clinic staff. A laboratory technician from the Water Department performed all bacteriological analyses at the Pirimiti Mission. Five young women, secondary school leavers, were trained and hired as enumerators. A typist was hired for one month as the data entry operator for the computer data storage.

Data Collection

Two questionnaires were administered to the mother of each selected child; a short one at the clinic and a more detailed one at the family home. Both questionnaires, in Chichewa and translated English, are attached as Annex B1. Clinic information collected by the nurse or field supervisor consisted of disease details, sex, age,height, weight, family identification, village, and water source. Age was determined from date of birth, height from supine length and weight from a 25 kg Salter spring balance scale.

Household interviews were conducted by the 5 enumerators who bicycled to the various villages daily. They had received 2 weeks of training at the Centre for Social Research, including some field work when the questionnaires and clinic selection procedures were pre-tested. The household interview covered water collection, storage and use, health education, hygiene, sanitation and several questions on work, social and educational status. The enumerators observed and measured the water collection pots, paced the distance to the water source and collected water samples from the source and home for bacteriological analyses.

Validity checks were made on 63 (8%) of the 801 completed household questionnaires by the field supervisor. He revisited the households to check the reliability of 8 specific questions. Five percent of the questionnaires checked had major problems - either the enumerator had fabricated the data or interviewed the wrong person. Another 3% had minor reporting errors on a single question. Overall, 95% of the checked questions had correct information as reported by the family member.

Field Problems

There were expected and unavoidable difficulties in traveling to the villages during the rainy season and in locating some of the selected families. Exceptionally heavy rains caused bridge washouts and impassable roads, creating delays in interviewing. Due to difficulties in reaching certain villages and locating houses (erroneous direction were occasionally given) 5% of the cases and 4% of the controls had no household interview.

The heavy rains caused even greater problems for the piped water system: floods and shifting soil caused 3 major pipeline breaks and one minor one in the study area. Three pipelines crossing the Thondwe River were broken by swift currents and debris, affecting 206 water taps. Repairs took around 2 months for each of these breaks. Another break in the main distribution line caused 334 water taps to be without water for around 10 days. These changes in water service created a variable percent of the population using piped water during the study period. This variation complicates the epidemiologic analysis of the data. It also made it more difficult to determine what type of water the child had used prior to becoming ill. Particular attention was paid to this question during "change-over" periods in water service.

Water Quality Sampling and Analysis

As mentioned previously, water samples were collected from some of the water sources and houses for bacteriologic analysis. One-third (107) of the piped water taps and homes using them were sampled, half of the 37 boreholes and one-third (147) of other unprotected sources and homes were sampled. The selection of sources to be sampled was random. A house using each source was sampled so there were pairs of source-house data to compare for changes in water quality.

The water sources and vessels were sampled in the manner water would normally be collected or drawn from them. Taps were not sterilized nor was the family's fetching cup or gourd. Samples were collected and stored in sterile polyethylene bags ("Whirl-Bags") before analysis. Analyses were always run the same day usually within 1-4 hours of sample collection. Fecal coliform (FC) and fecal streptococci (FS) were enumerated using the membrane filtration technique with Millipore field testing kits and incubators (Lewis, 1984).

Diarrheal Etiologies

Two months into the field work, arrangements were made with a South African laboratory to test stool samples and rectal swabs for diarrheal pathogens. Supplies were shipped from the South African Institute of Medical Research in Johannesburg and samples returned there within 2 weeks of collection.

Fresh stool samples were collected from the subjects when possible, and rectal swabs were obtained otherwise. Stool samples were collected from 24 diarrhea cases and rectal swabs from another 24 cases. Ten stool samples and 31 rectal swabs were collected from controls. Bacteriological samples were preserved in Amies medium and parasitological samples in polyvinylalcohol. All samples, including viral, were refrigerated at Pirimiti Mission from 1 to 6 days before refrigerated air shipment to SAIMR. Air shipment took anywhere from 1 to 7 days, but samples were always kept chilled.

Standard bacteriological procedures were used to isolate and identify *Escherichia coli* strains with diarrheic potential, salmonellae, shigellae, *Aeromonas hydrophila* strains and *Campylobacter jejuni* organisms (Freiman et al., 1977; Richardson et al., 1983). The *E. Coli* isolates were serogrouped with a panel of sera representing the classical enteropathogenic *E. coli* (EPEC) and enteroinvasive (EIEC) serogroups. All *E. coli* isolates were tested for the production of heat-labile enterotoxin using a tissue culture technique and for heat-stabile enterotoxin in baby mice. Only isolates that belonged to EIEC serotypes were tested for enteroinvasive potential in guinea pig conjunctivae (Sereny's test).

All stool samples were checked for rotavirus using the enzyme-linked immunosorbent assay (ELISA) (Schoub et al., 1982). A DNA hybridization ("Dot Blot") technique was used for the determination of Adenoviruses types 40 and 41 which cause gastroenteritis (De Jong et al., 1983).

Parasitological stool samples were centrifuged after saline addition and then mixed with a merthiolate-formaldehyde solution and ether. This was centrifuged again and the pellet resuspended in merthiolate-formaldehyde before examination. In addition trichrome staining was carried out on all these stools.

Data Analysis

Data analysis was carried out on a microcomputer and the mainframe computer at the University of North Carolina using the statistical packages SYSTAT and SAS. Logistic regressoin analysis was used for the multivariate estimate of the risk odds ratio - the risk of diarrhea for a young child using traditional water supplies as compared to the risk of diarrhea for a young child using a piped water supply.

Anthropometric data were analyzed by a microcomputer program provided by the Centers for Disease Control. The reference population was one recommended by the US Academy of Sciences and the World Health Organization (Waterlow et al., 1977).

RESULTS

General

During the four month recruitment period, 399 children with diarrhea and 440 children with control diseases were selected. Household interviews were completed for 95% of those subjects. The number of diarrhea cases reporting to the clinics generally declined over the four months, as is typical with the passing of the warm, rainy season. Consequently the goal of 450 diarrhea cases was not reached.

The general characteristics of the children selected and their families were fairly uniform among the cases and controls. The distribution of selected variables among cases and controls is shown in Table 1. Half of the families followed a traditional subsistence farming lifestyle, while the other 50% engaged in business, trade or some outside employment for income. This is a comparable percentage of subsistence farmers to that found in the 1981 Centre for Social Research survey of Zomba East-south (Msukwa and Kandoole, 1981). The percentage of fishermen in the present survey was much smaller however (4% compared to 20% for the CSR survey), indicating that the remainder of households may have a higher economic status than that normally found.

The main ethnic group of the study population was Lomwe (47%) followed by Nyanja or Chewa (36%), Yao (15%) and other (2%). This distribution is typical for this area. The child's father was the head of household in 75% of the homes, the mother in 4% and a grandparent in 19% of the families. The average household size was 5.1 people. Mothers generally had little or no education (82% with less than Standard 5) but the mothers of control children were somewhat better educated than case mothers. Twenty-one percent of control mothers had reached Standard 5 or above as compared to 15% of case mothers.

The children selected were 49% female, 51% male with a slightly higher proportion of males among the cases. More controls than cases were in the age group 0-5.9 months, but this was balanced by the higher percentage of cases age 6-11.9 months. Each group had 55% of the children under 1 year of age and another 32% under 2 years.

The severity of the diseases, as judged by the duration of symptoms, was basically the same for the cases and controls: 30% had symptoms for one day or less, 64% for a week or less and the remainder for up to a month or more.

The nutritional status of the children was compared using three measurements: weight for height, height for age and weight for age. The diarrhea cases showed more evidence of current malnutrition since 15.4% were more than two standard deviations (SD) below the median weight for height for the reference population. The comparable figure for the controls was 9.6% <-2 SD weight for height. The details of these measurements by age group are presented in Tables 2 and 3. In a March 1984 survey of 2 communities in the western part of the Zomba

Table 1

Distribution of Selected Variables in Cases and Controls
(Percents unless otherwise indicated)

	Cases	Controls
Occupation of Household Heads:		
Subsistence Farmer	50	49
Commercial Farmer	10	10
Businessman	20	19
Fisherman	5	3
Other	15	19
Head of Household (relation to child):		
Father	75	76
Grandparent	19	19
Mother	5	3
Other	1	2
Mother's Education:		
None	57	53
Standard 1-4	28	26
Standard 5-8	15	18
Form 1-2	<1	3
Mother's Age:		
Range	15-50	15-49
Average	26	27
Household Size:		
Range	2-17	2-20
Average	4.9	5.2
Family Tribe:		
Lomwe	46	47
Nyanja, Chewa	39	34
Yao	13	16
Other	2	3
Child's Age, months:		
0-5.9	20	30
6-11.9	35	25
12-17.9	22	19
18-23.9	11	12
≥24	12	14
Child's Sex:		
Male	54	49
Female	46	51

Table 1 (continued)

	Cases	Controls
Child Feeding:		
Breastfed Only	4	7
Breastfed & Supplements	77	74
Not Breastfed	19	19
Duration of Disease Symptoms:		
Day	30	31
Week	64	64
Up to 1 month	5	3
> month	1	2
Nutrition Indicators:		
Weight for Height, % < -2 S.D.	15.4	9.6
Height for Age, % < -2 S.D.	31.3	31.2
Weight for Age, % < -2 S.D.	37.7	28.8

Table 2

Percentage of Cases by Height for Age by Weight for Height (SD Score)

	WT/HT SD				
Ht/Ag SD	Over -1.00	-1 to -1.99	-2 to -2.99	-3 and less	Total
Over 1.00	10	7	4	0	21
	2.7	1.9	1.1	0.0	5.6
1.0 to -0.99	88	26	11	2	127
	23.6	7.0	2.9	0.5	34.0
-1.0 to -1.99	47	42	15	2	106
	12.6	11.3	4.0	0.5	28.4
-2.0 to -2.99	35	21	10	5	71
	9.4	5.6	2.7	1.3	19.0
-3.0 and less	25	15	5	3	48
	6.7	4.0	1.3	0.8	12.9
TOTAL	205	111	45	12	373
	55.0	29.8	12.1	3.2	100.0

Table 3

Percentage of Controls by Height for Age by Weight for Height (SD Score)

	WT/HT SD				
Ht/Ag SD	Over -1.00	-1 to -1.99	-2 to -2.99	-3 and less	Total
Over 1.00	12	3	0	4	19
	2.9	0.7	0.0	1.0	4.5
1.0 to -0.99	109	21	13	1	144
	26.0	5.0	3.1	0.2	34.4
-1.0 to -1.99	81	38	8	1	128
	19.3	9.1	1.9	0.2	30.5
-2.0 to -2.99	54	20	7	0	81
	12.9	4.8	1.7	0.0	19.3
-3.0 and less	27	14	5	1	47
	6.4	3.3	1.2	0.2	11.2
TOTAL	283	96	33	7	419
	67.5	22.9	7.9	1.7	100.0

district, 9.9% and 8.8% of the children were less than -2 SD weight for height using the same reference population (Lindskog, 1984). Given that the present study was of sick children reporting to the clinics and the other was a general population survey, only the diarrhea cases show increased wasting.

The groups of cases and controls both show the same degree of previous malnutrition as evidenced in the height for age index. 31.3% of cases and 32.2% of controls could be considered short since they were less than 2 SD from the median for the reference population. Tables 4 and 5 present the relationships for height for age thus SD scores at various ages. The weight for age SD score distributions were similar to those for height for age. 37.7% of cases were less than -2 SD and 28.8% of controls were likewise. The "deficiencies" in weight for age are thus a reflection more of small stature than of current malnutrition with the differences between the two groups evidence of malnutrition for the diarrhea cases. These figures were prepared for a comparison of the two selected groups of sick children and should not be considered representative of the child population at large.

Water Collection and Use

The mothers of the selected children were initially asked at the clinic what water source they used for drinking water. Subsequently this response was checked during the household interview by further questioning and a visit to the water source. The home response was considered the correct one since it was verified through observation. The clinic responses were not always reliable, due to either a misunderstanding of the question, a perceived need to respond falsely or an actual change in water sources due to pipeline breaks. Eight percent of those using piped water had answered differently at the clinic and 11% of those using other sources had said they used piped water. A total 19.6% responded differently at home than at the clinic.

Users of a particular water source for drinking also generally used it for cooking, washing food and utensils and bathing their child. Only 3% used a source different from their drinking water source for these purposes. However 55% of the surveyed population used a different water source for clothes washing and that source was usually the river. Table 6 details the choices for clothes washing sources. Water was brought to over 80% of the households for both men's and women's bathing and for smearing floors. The majority of households also fetched water for making bricks and washing pounded maize. The various uses of water brought to the house, other than drinking and cooking, are shown in Table 7.

Almost all the water collectors are women and girls with only an occasional young boy assisting. Eighty-one percent are over 14 years old, 16% 10-14 years and 3% are less than 10 years old. Most of the households (88%) have one or two collectors. The distance they must walk averaged 200 meters, one way. The closest sources were unprotected wells which averaged 170 meters from the house, then piped water taps which were 220 meters away, next were boreholes at a distance of 290

Table 4

Percentage of Cases by Age by Height for Age

Age, Months	Over -1.00	WT/HT SD -1 to -1.99	-2 to -2.99	-3 and Less	Total
0-5.9	55	15	9	1	80
	68.8	18.8	11.3	1.3	100.0
6-11.9	65	39	16	15	135
	48.1	28.9	11.9	11.1	100.0
12-23.9	27	43	32	25	127
	21.3	33.9	25.2	19.7	100.0
>=24	7	15	16	7	45
	15.6	33.3	35.6	15.6	100.0
TOTAL	154	112	73	48	387
	39.8	28.9	18.9	12.4	100.0

Table 5

Percentage of Controls by Age by Height for Age

Age, Months	Over -1.00	WT/HT SD -1 to -1.99	-2 to -2.99	-3 and Less	Total
0-5.9	81	30	10	9	130
	62.3	23.1	7.7	6.9	100.0
6-11.9	43	35	23	8	109
	39.4	32.1	21.1	7.3	100.0
12-23.9	29	45	37	21	132
	22.0	34.1	28.0	15.9	100.0
>=24	13	21	16	11	61
	21.3	34.4	26.2	18.0	100.0
TOTAL	166	131	86	49	432
	38.4	30.3	19.9	11.3	100.0

Table 6

Percent of Population Using Various Water Sources for Clothes Washing

Clothes Washing Sources	Drinking Water Source			
	Piped Water	Borehole	Unprotected Well	River
Piped water	44	-	-	-
Borehole	-	35	-	-
Unprotected well	9	16	46	-
River	47	49	54	100

Table 7

Percent of Population Bringing Water to Home for Various Activities

Activity	DRINKING WATER SOURCE				
	Piped Water	Borehole	Unprotected Well	River	TOTAL
Men bathing	83	78	78	56	80
Women bathing	86	95	83	33	84
Washing clothes	44	35	31	0	36
Watering animals	26	22	19	33	22
Smearing floors	89	92	97	89	93
making bricks	63	76	64	89	64
Washing pounded maize	77	84	64	33	70

meters and last the rivers at an average 330 meters. These values are presented in Table 8.

The quantity of water used averaged 31 liters per capita per day (lcd). The amount used varied little by water source, with piped water users averaged 29 lcd, borehole users 34 and users of unprotected wells 32 lcd. These figures are high compared to the usage surveys conducted by the Centre for Social Research and the Water Department; consumption of 10-20 lcd has been previously reported (Msukwa, 1981; Ettema, 1983). The present estimates may be biased due to two factors: method of measurement and enumerator influence. Water collection containers were observed and measured, and the number fetched each day was reported by the mother. The tendency to report a maximum daily usage or overreport is probably stronger than the probability of underreporting. Also the phrasing of the question could have influenced the response. Enumerator influence is evidenced by the variation in average reported usage by enumerator. An analysis of variance showed that the variance among enumerators was significant ($p<0.01$) and that enumerators accounted for more of the variation in reported water use than did the type of water source. Such bias is an unfortunate outcome of survey methodology but important to acknowledge when the survey relies on questioning and self reporting by the interviewee rather than on observation of actions. No further analysis of water quantity data was performed due to its questionable reliability.

The water collection and storage practices were almost uniform regardless of what water source the household used. As shown in Table 9, 95% of the households kept their water inside, 69% kept the pot covered, 95% extracted water using a cup with a handle and 42% used the same container for fetching and storing water. Thus with the exception of the last practice, the majority of the population used good storage practices which can minimize the possibility of further water contamination. The effect of such practices on water quality will be discussed in the next section.

Water Quality

Water samples were analyzed for the presence of two bacterial indicators of fecal pollution, fecal coliforms and fecal streptococci. International standards and guidelines usually specify testing drinking water supplies for total coliforms and fecal coliforms (World Health Organization, 1984). Since total coliform organisms derive from soil and vegetation as well as feces, their presence does not always indicate fecal contamination, however. Therefore, as is now routine in studies of this type, the more specific test for fecal coliforms (FC), found in the feces of warm-blooded animals, was performed. It should be recognized that the fecal coliform analysis does not distinguish between human and animal fecal contamination.

Enumeration of fecal streptococci (FS) as a secondary indicator organism was also performed because this group has often been used to test the quality of streams and lakes. Fecal streptococci are present in large numbers in human feces, though less numerous than the coliform

Table 8

Distance to Drinking Water Sources

Water Source	Number Surveyed	Average Distance meters	Standard Deviation meters
Piped water tap	315	218	143
Borehole	36	294	204
Unprotected well	436	169	146
River	9	327	191

Table 9

Water Collection and Storage Practices by Water Source

	Drinking Water Source			
Practice	Piped Water	Borehole	Unprotected Well	River
Container inside	95%	100%	94%	100%
Container outside	5	0	6	0
Container covered	70	70	67	67
Container not covered	30	30	33	33
Use cup with handle	94	95	95	100
Use cup without handle	6	5	5	0
Same container for fetching/storing	42	35	43	56
Different container for fetching/storing	58	65	57	44

group. Generally, streptococci are more numerous than coliform in animal feces which has led to the use of a FC/FS ratio to determine the source (animal or human) of fecal contamination. Much controversy surrounds the appropriateness and validity of this ratio, however, and its use is not recommended (Feachem et al., 1983). For this report, the FC results are used as the primary criteria for judging water quality, and the FS results supply secondary supporting evidence.

The fecal coliform and fecal streptococci counts observed in samples collected at the water sources and in the homes are presented in Tables 10 and 11. The logarithmic transformation which provides the geometric mean dampens the effect of a few isolated high counts. Also log transformations of bacterial counts more accurately reflect the dose-response relationship between pathogens and probability of infection. The FC and FS distributions for the source and home samples are presented in Figures 1-4.

The FC and FS levels were significantly lower ($p<0.001$) in the samples from taps and houses using taps than the average levels in other sources of water. Fifty percent of the samples from taps and houses using taps had an FC count of 10 or less colonies/100 ml. This is exceptionally good quality for an untreated supply. The geometric mean FC count showed no noticeable deterioration from tap to house, being 12 colonies/100 ml at the tap and 16 at the house.

Borehole water quality was slightly worse than that of piped water with a mean FC of 46 colonies/100 ml at the source and 235 in the home. This difference between source and home is not significant (either because there is no true difference or because the sample size is small). It should be noted that the quality of water from these old boreholes - which often have cracked slabs - is much worse than that found in the newer project boreholes which typically deliver water with less than 10 fecal coliforms and 20 FS per 100 ml (Lewis, 1984).

The unprotected sources had variable quality, but it was substantially worse than either the taps or boreholes. Fourteen percent of the samples had no FC, yet the other 84% had counts over 100/100 ml. The distribution in the households followed a similar pattern. Overall the average quality between source and house changed little considering the high counts found in the source. The average quality was 540 FC colonies/100 ml at the source and 760 FC colonies/100 ml in the home. The quality of water from unprotected sources and boreholes improved as the heavy rains subsided, explaining some of the lower values. [Thus in the peak diarrhea season (rainy) the difference in water quality between protected and unprotected sources is greater than other times.]

Fecal streptococci values were at least an order of magnitude higher than the counterpart fecal coliform values for source and house samples. This agrees with findings of the Central Water Laboratory (Lewis, 1984). Their studies have shown that FS are more predominant than FC organisms irrespective of season or water source.

Perhaps the most striking conclusion drawn from these results is the overall good water quality (as measured with FC) found in homes using

Table 10

Fecal Coliform Means
Colonies/100 ml

Sample Location		Number Samples	Mean,* Col/100 ml
Piped Water:	Source	107	12
	House	104	16
Borehole:	Source	20	46
	House	20	240
Unprotected Wells & River:	Source	146	540
	House	147	760

* Geometric Mean

Table 11

Fecal Streptococci Means
Colonies/100 ml

Sample Location		Number Samples	Mean,* Col/100 ml
Piped Water:	Source	100	280
	House	94	1100
Borehole:	Source	20	770
	House	20	2740
Unprotected Wells & River:	Source	141	3900
	House	142	4780

*Geometric Mean

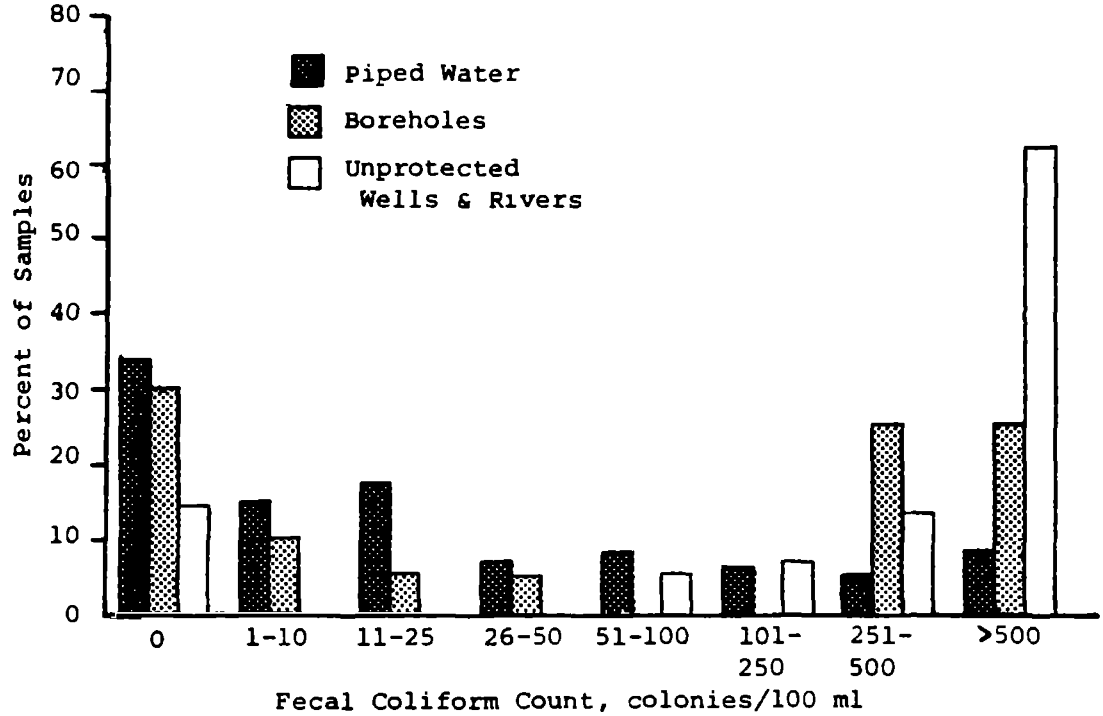

FIGURE 1. PERCENTAGE DISTRIBUTION OF WATER SOURCE SAMPLES BY FECAL COLIFORM COUNTS

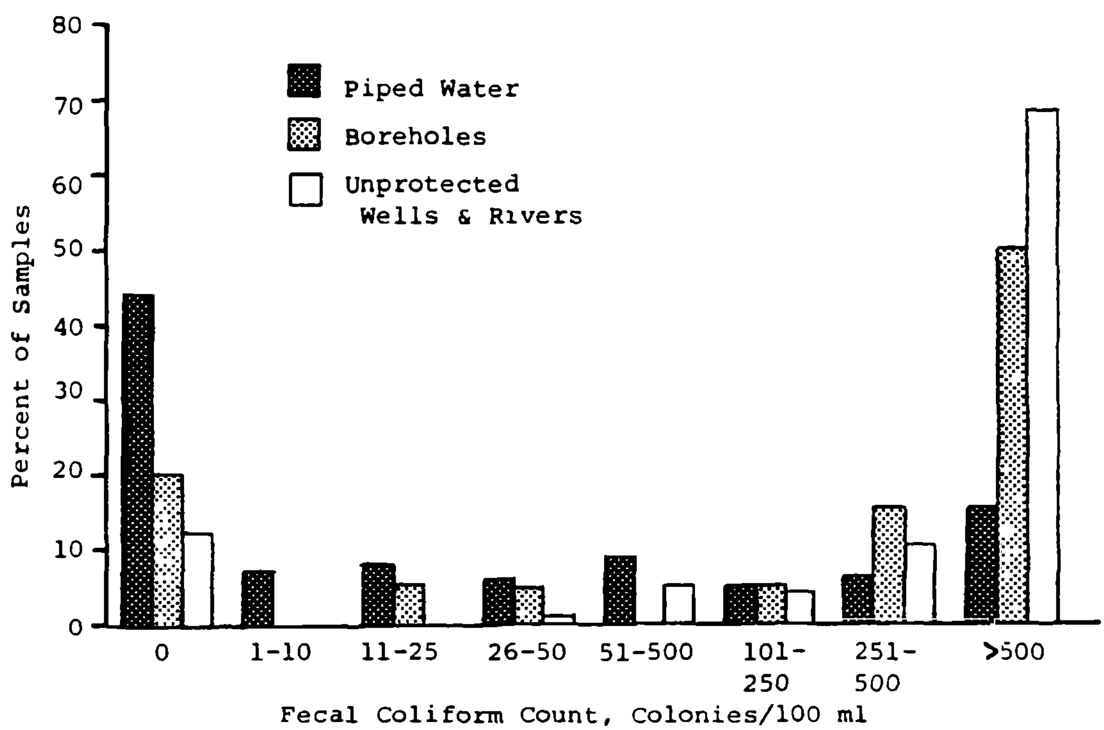

FIGURE 2. PERCENTAGE DISTRIBUTION OF HOUSE SAMPLES BY FECAL COLIFORM COUNT

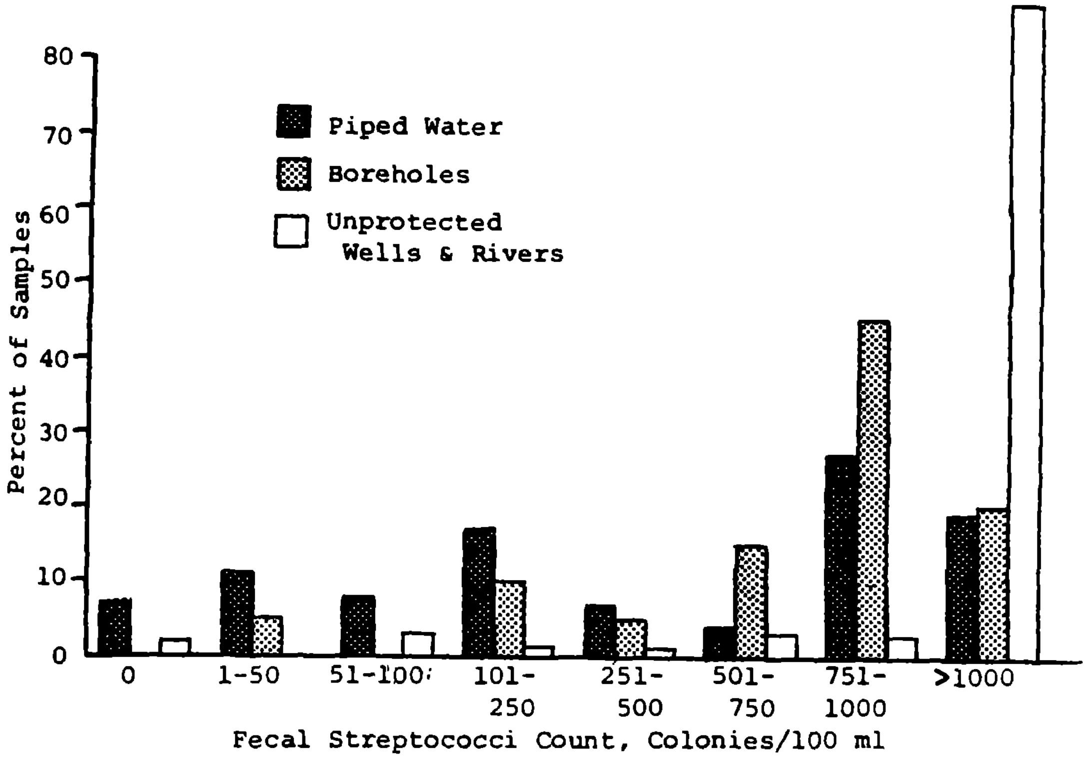

FIGURE 3. PERCENTAGE DISTRIBUTION OF WATER SOURCE SAMPLES BY FECAL STREPTOCOCCI COUNTS

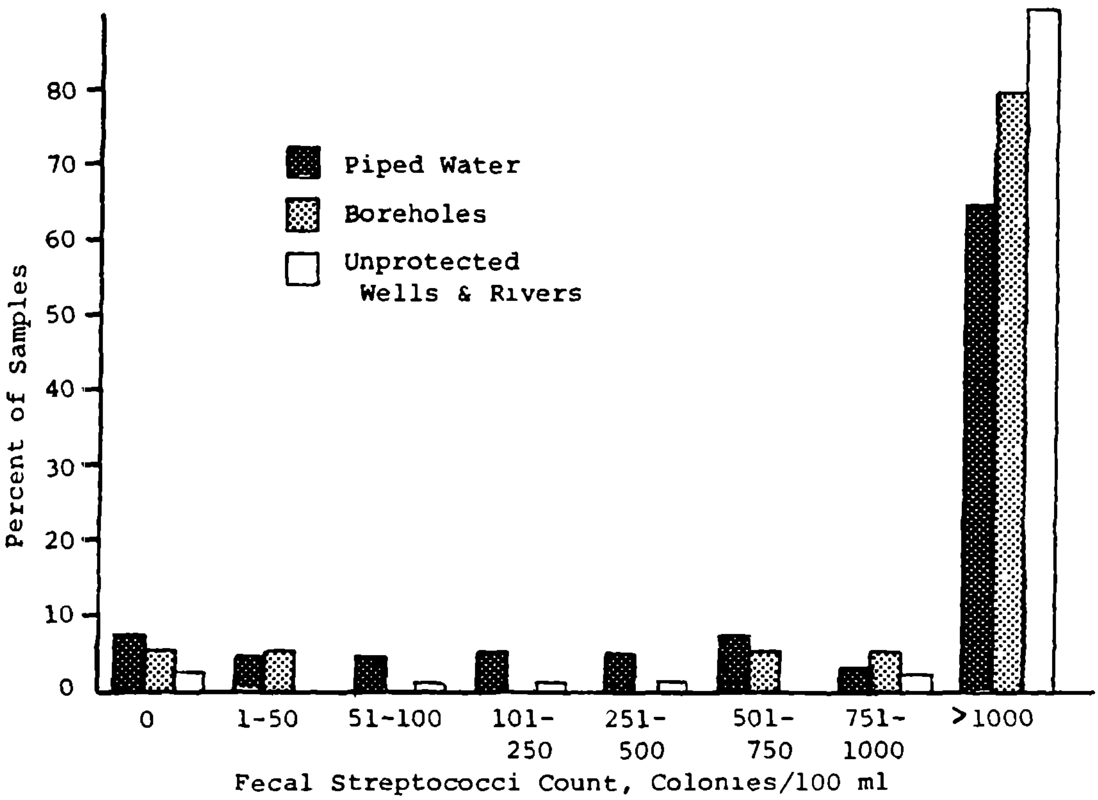

FIGURE 4. PERCENTAGE DISTRIBUTION OF HOUSE SAMPLES BY FECAL STREPTOCOCCI COUNTS

tap water. The water collection and storage habits were investigated to see if the tap users had better hygiene practices than the other population. The habits were similar in all the groups. Almost all women stored their water inside the house. The covering and fetching habits varied but there was no relationship between these practices and water sources. An analysis of variance was performed to assess the effect on household water quality (FC logarithmic values) of: water source, where jar stored, whether jar covered, whether dipping cup had handle and whether the same or different jar was used for fetching and storing the water. The only highly significant association with household water quality was the source of the water ($p<0.01$). Whether the same jar was used for fetching and storing showed some association to household water quality ($p<0.10$). Thus when comparing different water sources in the Zomba East area, we see that the water source is the main determinant of the quality of water that the people will actually be drinking. Since there is little variation in collection and storage practices, little association with changes in water quality can be expected. The population in this area generally ascribes to those practices which are promoted to reduce water contamination. From these results these practices seem to be successful.

A recent survey of water quality in 198 households using tap water in western Zomba district has shown different results (Lindskog, 1985). There, collection and storage practices appear to be more variable and show a significant association with water quality in the home. Storing water outside, uncovered and the in the same container as used for collection are correlated with lower FC counts. The contrast in these results from Zomba West and those from Zomba East might be accounted for by: 1) the different treatment of the data in analysis (Zomba West data were not transformed logarithmically), and 2) the lack of variation in storage practices for the Zomba East households. If the association between collection and storage practices and water quality in the home remains after the Zomba West data have been logarithmically transformed, then this finding has important implications for the health education program. [Statistical analysis procedures assume a normal distribution of the variable and the logarithmic transformation of bacterial counts more closely approximates the normal distribution than does their natural distribution.]

Diarrheal Etiologies

The pathogen isolation rates were higher among diarrhea cases than controls for viruses and parasites but the same for bacteria (Table 12). Thirty-four samples from cases and controls were examined for viruses and parasites, and 89 samples were examined for bacterial pathogens. Multiple pathogens were found in three diarrhea cases (12.5%) and one control case (10%) when all laboratory analyses could be conducted on the stool samples. Mixed infections were combinations of multiple bacteria (1), multiple bacteria and a parasite (1), multiple bacteria and rotavirus (1), and a bacterium and rotavirus (1). When a single diarrheic pathogen was detected in a sample it was a bacterium in 50% of the samples, a parasite in 36% and a virus in 14%.

Table 12

Diarrheal Pathogens Isolated in Malawi Samples

Viruses		Diarrhea Cases	Controls
Rotavirus		16.7% (4/24)	0% (0/10)
Adenovirus		0% (0/24)	0% (0/10)
	Overall	16.7% (4/24)	0% (0/10)
Bacteria			
E. coli isolates:[1]			
EPEC		8.3% (4/48)	4.9% (2/41)
ETEC		2.1% (1/48)	4.9% (2/41)
EIEC		8.3% (4/48)	17.1% (7/41)
Salmonellae		12.3% (6/48)	4.9% (2/41)
Shigella		0% (0/48)	0% (0/41)
Aeromonas hydrophila		0% (0/48)	2.4% (1/41)
Campylobacter jejuni		0% (0/48)	2.4% (1/41)
	Overall	27.1% (13/48)[2]	26.8% (11/41)[2]
Parasites			
Ascaris lumbricoides ova		4.2% (1/24)	10.0% (1/10)
Entamoeba coli cysts		8.3% (2/24)	0% (0/10)
Entamoeba histolytica cysts		4.2% (1/24)	0% (0/10)
Taenia sp. ova		4.2% (1/24)	0% (0/10)
Giardia lamblia cysts		4.2% (1/24)	0% (0/10)
	Overall	25.0% (6/24)	10.0% (1/10)

[1]The EPEC serogroups recovered from cases were 055 (2), 0119 (1) and 0142 (1). The 2 EPEC from controls comprised one isolate each 026 and 055. All EIEC strains typed were 0144.

[2]These figures count multiple pathogens per sample only once.

No significant differences for total isolation rate or group isolation rates were detected using Fisher's exact test.

Rotavirus was detected in 4 of the 34 examined samples, and those were all diarrhea cases. The isolation rate was 16.7% for cases and 0% for controls. This difference is not statistically significant due to the small sample size but does indicate a trend of rotavirus detection among clinically diagnosed diarrhea patients.

Bacteriological investigations revealed E. coli organisms in 80 out of 89 fecal samples (90%). Of the E. coli isolates, 25% were identified as diarrheal pathogens. Enteropathogenic E. coli (EPEC) were present in 7.5%, enterotoxigenic E. coli (ETEC) in 3.8% and enteroinvasive (EIEC) in 13.8% of stool and rectal swab samples. Other bacteria detected were Salmonellae in cases (12.3%) and controls (4.9%), Aeromonas hydrophila in one control and Campylobacter jejuni in one control. None of these isolation rates were significantly different, nor wre the overall bacterial isolation rates of 27.1% for cases and 26.8% for controls.

The presence of parasites in the stool was more common for cases (25%) than controls (10%). Ascaris lumbricoides ova were seen in 3 samples, Entamoeba coli cysts in 2 samples, and E. histolytica cysts, Taenia ova and Giardia lamblia each in one sample.

The overall isolation rate of 54% among diarrhea patients (who had an analyses performed) is good considering the difficulties in sample collection and shipment to South Africa. A study by the same medical laboratory, SAIMR, on black children admitted to a hospital for treatment of diarrhea and dehydration reported a pathogen isolation rate of 69% (Robins-Browne, 1980). Diarrhea due to noninfectious causes, extraintestinal infection, or dieoff of the organisms may account for some of the cases where no pathogen was detected. Although significant differences in isolation rates between the diarrhea patients and controls were not found, the trends seen in the viral and parasitological results indicate this may be more a function of small sample sizes than actual similarity. The similarity of bacterial isolation rates for diarrhea cases and controls is indicative of the asymptomatic presence of intestinal pathogens in the controls.

These results present a complex picture of childhood gastroenteritis, with a wide variety of contributing enteropathogens. An improved study of diarrheal etiologies would focus on the peak diarrheal months of December through February and have a larger sample size.

Health Impacts (Epidemiologic Results)

The risk of diarrhea associated with using unprotected water supplies (those other than piped water) was compared to the risk of diarrhea associated with using piped water supplies.[1] The relationship

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1 Since the focus of this investigation was the rural piped water system, that water source was contrasted to all others grouped together. A subsequent model was developed contrasting piped water and boreholes to unprotected wells and rivers. The change in the risk odds ratio estimates was negligible, and thus only the one model is presented here.

between these two risks is established by estimating the risk odds ratio. This is the ratio between the odds of having diarrhea given that one uses an unprotected water source and the odds of having diarrhea given that one uses piped water. The details of the analysis strategy and methods are presented in Annex B2. Many variables were included in the model other than disease status and water supply (see Table 1, Annex B2). Of particular interest are: latrine, breastfeeding and mother's education. These were specified as "effect modifiers" because the effect of the piped water on diarrhea could be increased or decreased depending on the status of these variables (e.g. latrine, no latrine). Thus all estimates of the risk odds ratio (ROR) are referenced to the particular categories of these 3 variables. The latrine variable was categorized by whether the family did or did not have a latrine. The child's breastfeeding status could be: breastfed only, breastfed and given supplements, or not breastfed. Mother's education was grouped: none, some. The majority of children studied were breastfed and given supplements, and 45% of their mothers had education of Standard 1 or more. About half of the families (48%) had latrines.

The risk odds ratio estimates are presented in Figures 5-6 and in the tables in Annex B3. The format for presentation is one of combining the water supply and latrine conditions into four categories and comparing the relative risks between those. Thus the risks of diarrhea associated with having an unprotected water supply, or having no latrine or having both were estimated. Figure 5 presents the RORs for the children of uneducated mothers. Each diagram can be viewed as a progression from the "worst case" of an unprotected water source and no latrine to the first step of an improvement in either water or latrine to the second step of having both improved water (piped) and a latrine. The closer the ROR is to 1.0 the less difference in risk there is between the two comparison groups. The further the ROR is from 1.0 (either above or below), the greater the risk difference between the two comparison groups. If the ROR is above 1.0 then there is a higher diarrhea risk associated with the condition of unprotected water source and/or no latrine. An ROR less than 1.0 would indicate a higher risk of diarrhea associated with an improvement in water and/or sanitation. For example, in Figure 5 for the breastfed-only group, the risk of diarrhea for children of families using an unprotected water supply and no latrine is about 5.7 times the risk for children whose families have a piped water supply and latrine.

The importance of the numbers presented is in the general trends indicated not in the absolute estimates of the risk odds ratios. As can be seen from the tables in Annex B3, 95% confidence intervals of the point estimates are quite wide and thus the precision of the ROR estimates is rather poor. However, if our attention is directed to the trends observed in the estimates, some interesting points arise. The group of children who benefit most from improvements in water and sanitation are those who are exclusively breastfed. They have the highest risk odds ratio for diarrhea when the family uses an unprotected water supply and has no latrine. The children who are breastfed and given supplements or who are not breastfed at all always have lower RORs. This pattern is true for both the education categories shown in

FIGURE 5. RISK ODDS RATIOS for Children whose Mothers have NO EDUCATION

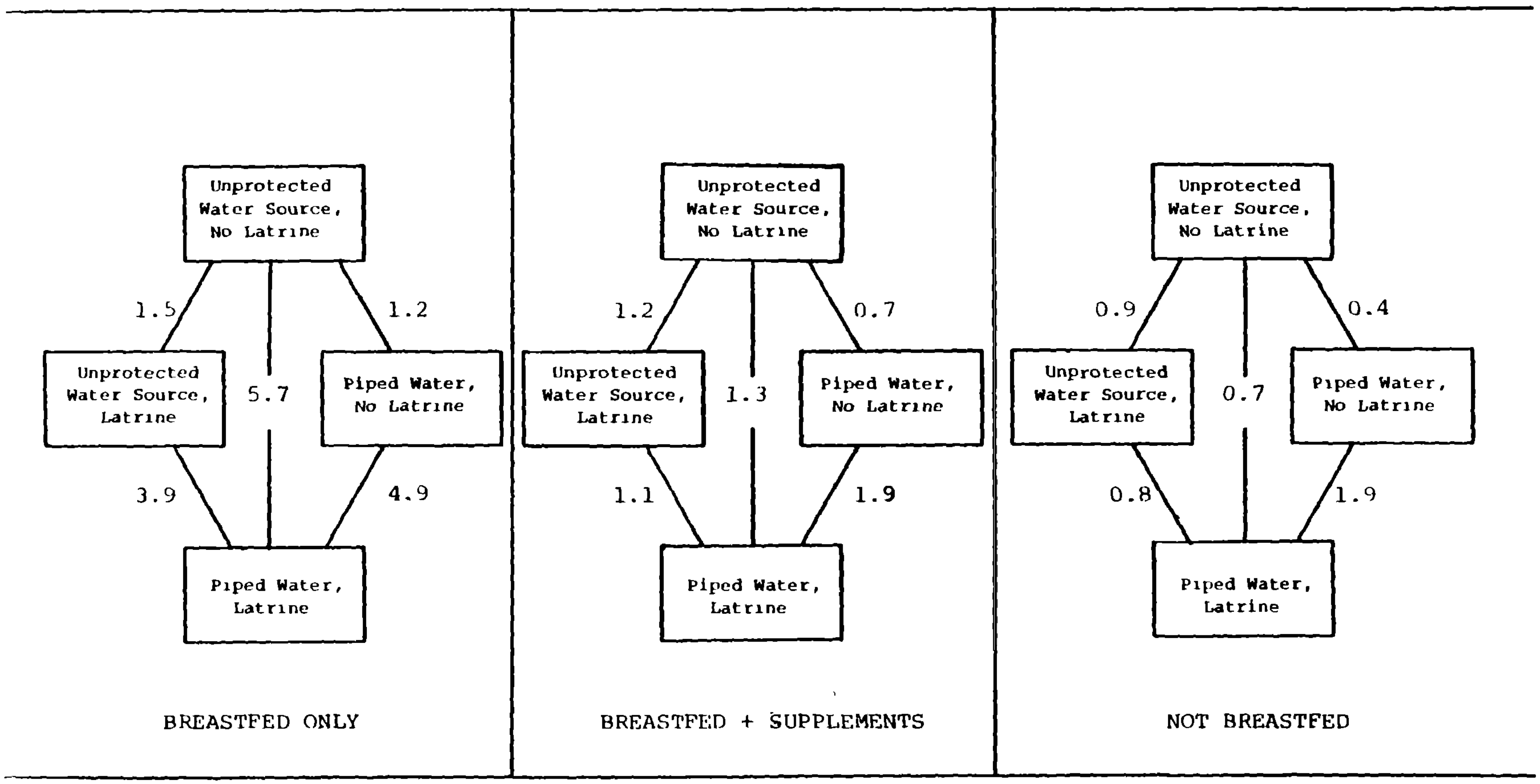
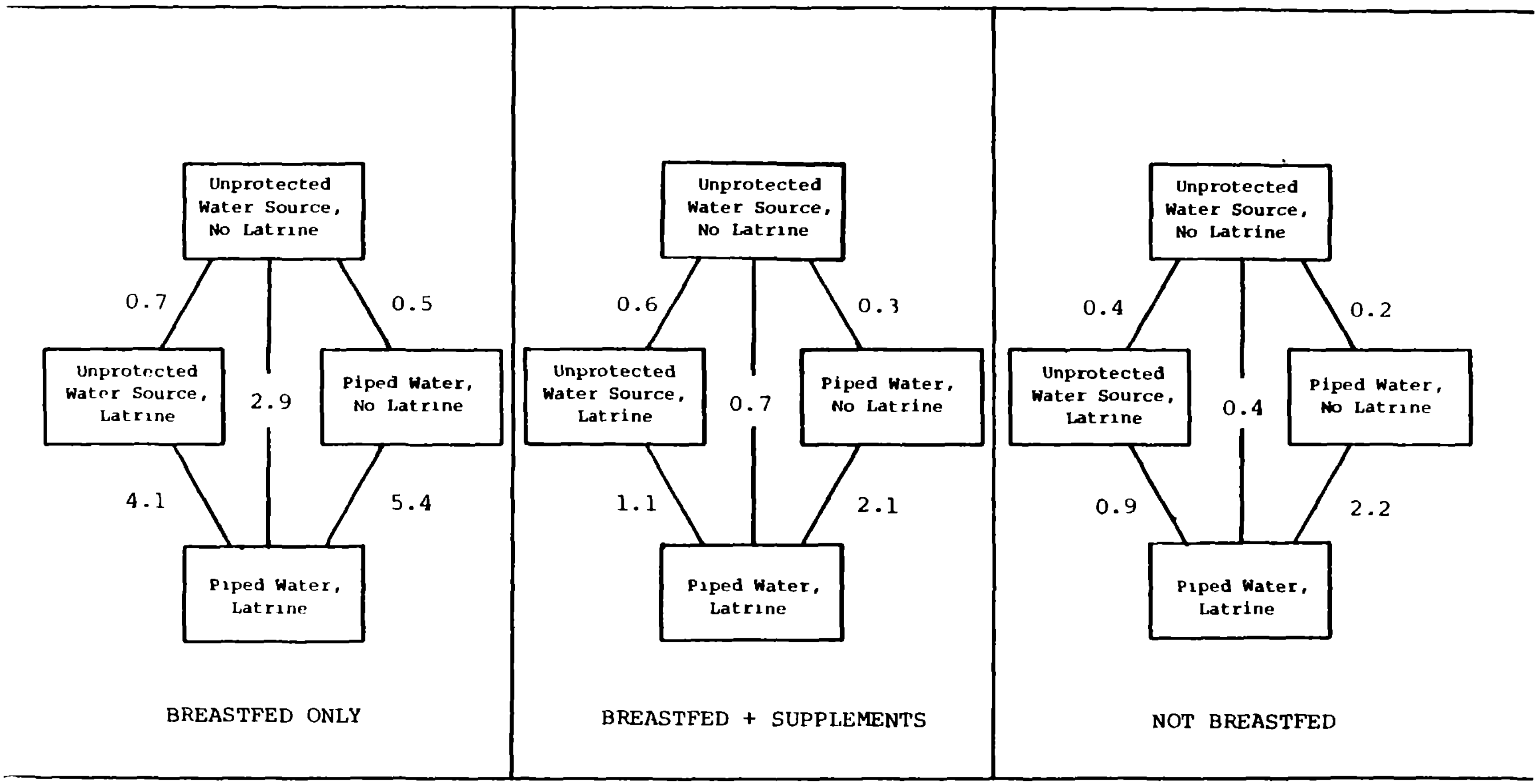


FIGURE 6. RISK ODDS RATIOS for Children whose Mothers have SOME EDUCATION



Figures 5-6. The beneficial effects of environmental improvements decrease as a child has more exposure to external food, being lowest for those children not breastfed.

This pattern is understandable given that the risk odds ratio estimates the risk of diarrhea associated with a more contaminated environment (unprotected water supply and no latrine) relative to a less contaminated environment (piped water and latrine). Those children who are not breastfed or are given supplemental food are subject to the bacterial transmission route via food. Reductions in bacterial exposure due to water and sanitation improvements may not be associated with a measurable decrease in diarrhea incidence due to the continued bacterial transmission through food. For those children who are exclusively breastfed, however, external food sources do not increase their bacterial exposure, while a contaminated water source (these children are given water) or poor sanitation on the caregivers part would. Improvements in these bacterial transmission routes should have a more dramatic effect on children who are breastfed only than those who receive additional food. The higher RORs for the breastfed only group express this phenomenon; the relative difference in risks of diarrhea between conditions of unimproved water and sanitation and improved water and sanitation is great, resulting in higher values of the risk odds ratios.

Improvements in water, sanitation and personal hygiene will reduce exposure to pathogens, but the remaining level of exposure to microorganisms after such interventions plays the important role in disease outcome. A major reduction in pathogen exposure may not produce a major or even measurable reduction in disease incidence because of a nonlinear dose-response relationship. "The implication is that the effect of improvements in, say, water quality should not be evaluated by the reduction in disease due to water supply improvements in isolation, but rather by the degree to which the improvement in water quality affects the health effects of other (simultaneous or subsequent) essential changes in environmental conditions or personal health practices" (Briscoe, 1984).

This was observed for those children who were breastfed only and were more receptive to water and sanitation improvements. This is also clearly demonstrated for the enhanced effect of combined water and sanitation improvements over a solitary improvement in either water or sanitation. The diagrams in Figures 5-6 present the RORs for the effects of having piped water or a latrine, without the other, as compared to the effects of having both. The presence of both piped water and a latrine is associated with a lower risk of diarrhea than the presence of just piped water or a latrine.

This can be more clearly seen in Table 13 which compares the RORs associated with the improvement in water supply when there are not latrines to when there are latrines. The ratio of these RORs (4th column) effectively yields an estimate of the enhanced risk reduction from providing both water and sanitation improvements rather than solitary water improvements. For the group with no education of

Table 13

Effect of Combined Piped Water and Latrines
Compared to Piped Water Only

Mother's Education	Child's Breastfeeding Status	(1) Piped Water and Latrine	(2) Piped Water No Latrine	Ratio (1):(2)
NONE:	Breastfed Only	3.87	1.18	3.3
	Breastfed & Supplements	1.07	0.68	1.6
	Not Breastfed	0.82	0.36	2.3
SOME:	Breastfed Only	4.05	0.54	7.5
	Breastfed & Supplements	1.12	0.31	3.6
	Not Breastfed	0.86	0.16	5.4

mothers, the combined water and latrine improvements show 2 to 3 times the risk reduction observed with water improvement only. The children whose mothers have some education benefitted 4-8 times more from both piped water and latrines than just piped water. Similar figures could be prepared comparing the combined effects of water and latrines to latrines only, and the ratios would be the same as those shown in Table 13. Whether the solitary improvement was latrines or piped water, the combined improvement in water and latrines always resulted in greater risk reduction than just an isolated improvement.

The majority of the children in this study were those who were breastfed and given supplements. For these children, an enhanced risk reduction of 2 to 4 was observed for the combined, as compared to isolated, improvements in water and sanitation.

CONCLUSIONS

This health impact evaluation of the rural piped water program focused on those very young children who are most susceptible to and most adversely affected by severe diarrhea. Essentially, it was a study of water-borne, as opposed to water-washed, diarrhea (Feachem et al., 1977) since the bacteriologic water quality of the piped water supply was significantly better than that of the alternative sources. Neither this study nor previous studies in Zomba East have found the quantity of water used in the rainy season to increase with piped supplies, since alternative water sources are abundant and easily accessible in this part of Malawi.

The improved bacteriologic quality of the piped water supply was maintained in the homes of the users as well. Generally the women in this study ascribed to good water collection and storage practices, regardless of their drinking water source. Household water quality deteriorated little if any from the source quality, and this may be attributed to the practices of storing water inside and covered, and using a cup with a handle for water extraction.

The risks of diarrhea associated with the use of piped water were minimized when other environmental improvements in sanitation and food had been made. For those children who had the benefit of being breastfed only, thus having little bacterial contamination of food, the complementary effect of piped water, latrines and breastfeeding reduced the risk of diarrhea 3 to 8 times the amount when only improved water or sanitation was provided. For those children who were not exclusively breastfed, the positive effect of piped water and latrines associated with diarrhea risk was 2 to 5 times greater than the effect of a solitary improvement in water or sanitation. When piped water or latrines were available, but as an isolated health intervention, no reduction in the risk of diarrhea was observed.

The results of this study are specific to the population in the eastern part of the Zomba district who use the health clinics during the months of January-May. In that there may be some characteristic differences between clinic users and the general population, such as a higher socio-economic status or greater health awareness, these results cannot be casually applied to the population at large. With the understanding that the basic disease process will be affected by sequential or simultaneous health interventions, regardless of the person however, the heightened effects of a combined water, sanitation, health education program can be assumed. The reduction in risks of diarrhea for young children in general may be somewhat less than those found in the case-control study. The children studied may be more receptive to environmental improvements due to the mother's or family's overall attention to health. Also, since the timing of the study coincided with the yearly peak of diarrhea in children 0-4 years old during the rainy season, an annual impact on diarrhea incidence would not be projected at the same levels. Notwithstanding, the transmission routes of poor water, food and sanitation do have a clear association with clinically diagnosed diarrheas during those critical months of diarrheal morbidity.

The need for health intervention programs which couple improved environmental services and hygiene is obvious. An isolated intervention may not be accompanied by the meaningful health improvements which are so often assumed. For diarrheal diseases which are of great consequence in both child morbidity and mortality, pathogen exposure is the result of many sources. As shown in this study, a coordinated program which addresses the major fecal-oral transmission routes - poor water, food and personal hygiene - has the greatest potential for measurable success in improving the health of these vulnerable young children. The decision by the Government of Malawi to couple water supply programs with health education and sanitation programs is clearly a wise choice and should be strongly encouraged.

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CLINIC FORM

I.D. Number ☐☐☐☐

Date Day ☐☐ Month ☐☐

Interviewer: ____________________

Clinic: 1☐ Pirimiti 3☐ Sitima
2☐ Chamba Dispensary

ASK OF THE CLINIC WORKER OR GET FROM THE CLINIC CARD:

1.1 What is the primary disease diagnosis?
1☐ Diarrhea 4☐ Measles
2☐ Chickenpox 5☐ Malaria
3☐ Whooping Cough 6☐ Symptoms referable to respiratory system

1.2 Does the child have diarrhea?
1☐ Yes
2☐ No (If No, SKIP TO Q. 1.5)

1.3 What are the symptoms of diarrhea?
1☐ Dehydration and watery diarrhea or 4 or more loose stools in the last day
2☐ Mucus and bloody diarrhea with fever
3☐ Mild diarrhea

1.4 Is the diarrhea associated with measles, malaria or malnutrition?
1☐ Measles 4☐ No
2☐ Malaria 8☐ Don't know
3☐ Malnutrition

1.5 Date of birth ____________________
Age in months ____________________

1.6 Source of age:
1☐ Verified 3☐ Said to be known
2☐ Estimate

1.7 Sex:
1☐ Female
2☐ Male

ASK OF THE CHILD'S PARENT (or other adult who has brought the child to the clinic)

2.0 The government is choosing some of the children who come to this clinic to help in the study of diseases that are found here. We would be very happy if you would allow us to ask you a few questions about your child and your family. But you have the freedom to refuse if you do not want to participate. Everything you tell us is confidential and the child's name or your name will not appear in any of our reports. Will you answer a few questions now and then let a young lady visit at your house and ask you a few questions next week?

1☐ Yes

2☐ No (If no, then thank her and ask the next person)

2.1 Child's name: ______________________________

2.2 What is his father's name? ____________________

2.3 What is your name? ____________________________

2.4 What is your relation to the child?

1☐ Mother 4☐ Sister

2☐ Father 5☐ Other relative

3☐ Brother 6☐ Not a relative

2.5 From what tribal group does the child's family come?

1☐ Yao 8☐ Don't know

2☐ Lomwe 9☐ No response

3☐ Nyanja/Chewa 0☐ Other __________

4☐ Ngoni

2.6 When did this sickness start in the child? (the sickness you have come for today?)

1☐ Yesterday (within last 24 hours) 4☐ A month ago

2☐ Before yesterday but within last week 8☐ Don't know

3☐ Before last week but within last month 9☐ No response

2.7 Has the child come to the clinic since the beginning of the year? ☐

1☐ Yes 8☐ Don't know

2☐ No (SKIP TO Q. 2.10) 9☐ No response

2.8 Did the child come for the same sickness he has come for today? ☐

1☐ Yes 8☐ Don't know

2☐ No 9☐ No response

2.9 Was this child selected in this project then? ☐

1☐ Yes 8☐ Don't know

2☐ No 9☐ No response

2.10 Is there anyone within the child's family who had severe diarrhea last week? ☐

1☐ Yes 8☐ Don't know

2☐ No 9☐ No response

2.11 Where does the child's family fetch their drinking water? ☐

1☐ Pipe 6☐ Rainwater

2☐ Borehole 7☐ Spring

3☐ Protected well 8☐ Don't know

4☐ Unprotected well 9☐ No response

5☐ River 0☐ Other ________________

3.0 Now we need to arrange for the time and day when you want another lady to visit you at your house and ask you a few questions. What is a good time for you to be found at home?

1☐ Early in the morning 4☐ After 12 noon

2☐ Late in the morning 5☐ Afternoon

3☐ Near 12 noon 6☐ Anytime

3.1 Are there days you will not be found at home next week?

- 1 ☐ Monday
- 2 ☐ Tuesday
- 3 ☐ Wednesday
- 4 ☐ Thursday
- 5 ☐ Friday
- 6 ☐ Saturday
- 7 ☐ Sunday
- 8 ☐ Any day

If so, the lady I have mentioned will come on ..... and ..... time, as you have suggested. Now I would like to know where you live.

Village ______________________________

Traditional authority __________________________

How can I travel to reach your house? How would a person get to your house? (Nearby villages; missions or schools, stores, etc.)

____

____

____

NOW ASK THE PARENT (OR OTHER ADULT) IF YOU MAY TAKE SOME MEASUREMENTS OF THE CHILD

4.1 Weight:___________________(record in kilograms)

4.2 Height:___________________(record in centimeters)

IF THE CHILD'S MOTHER IS NOT THE PERSON YOU HAVE TALKED TO PLEASE FIND OUT THE MOTHER'S NAME ____

Thank you very much for your help. This is all I wanted to ask. Do you have any questions? I will be happy to answer them.

CLINIC FORM

I.D. Number

Day Month

Interviewer: ______________________________ Date

Clinic: 1 ☐ Pirimiti   3 ☐ Sitima

2 ☐ Chamba Dispensary

ASK OF THE CLINIC WORKER OR GET FROM THE CLINIC CARD:

1.1 What is the primary disease diagnosis?

1 ☐ Diarrhea   4 ☐ Measles

2 ☐ Chickenpox   5 ☐ Malaria

3 ☐ Whooping Cough   6 ☐ Symptoms referable to respiratory system

1.2 Does the child have diarrhea?

1 ☐ Yes

2 ☐ No (If No, SKIP TO Q. 1.5)

1.3 What are the symptoms of diarrhea?

1 ☐ Dehydration and watery diarrhea or 4 or more loose stools in the last day

2 ☐ Mucus and bloody diarrhea with fever

3 ☐ Mild diarrhea

1.4 Is the diarrhea associated with measles, malaria or malnutrition?

1 ☐ Measles   4 ☐ No

2 ☐ Malaria   8 ☐ Don't know

3 ☐ Malnutrition

1.5 Date of birth ______________________________

Age in months ______________________________

1.6 Source of age:

1 ☐ Verified   3 ☐ Said to be known

2 ☐ Estimate

1.7 Sex:

1 ☐ Female

2 ☐ Male

ASK OF THE CHILD'S PARENT (or other adult who has brought the child to the clinic)

2.0 Boma likusankha ena mwa ana amene amabwera ku Chipatala kuno kuti athandize pa ntchito yofufuza zifukwa zomwe zimayambitsa matenda amene akupezeka kuno. Tidzakondwera kwambiri ngati mungalole kuti tikufunseni mafunso pang'ono okhuza mwana wanu ndiponso banja lanu. Komabe muli ndi ufulu wonse kukana ngati simukufuna kuthandizapo ndi kutengapo mbali. Chirichonse chimene mutiuze, dzina lanu kapena la mwana wanu silidzatchulidwa m'malipoti ena aliwonse ayi. Mungathe kuyankha mafunso pang'ono palipano, ndipo kodi mungalole kuti mayi wina adzakuchezereni kunyumba kwanu ndikukufunsani timafunso tochepa sabata ya mawayi?

1☐ Inde

2☐ Ayi (Ngati ayankha Ayi, muyenera kumuthokoza nkusiya mafunso anu pomwepa osapitiriranso ayi)

2.1 Dzina la mwana: ______________________________

2.2 Dzina la bambo wa mwanayu ndani? ____________________

2.3 Dzina lanu ndani? ______________________________

2.4 Kodi mwanayu ndi ndani wanu?

1☐ Mayi wake weniweni
2☐ Bambo wake weniweni
3☐ Mchimwene wake weniweni
4☐ Mlongo wake weniweni
5☐ Chibale china
6☐ Palibe ubale

2.5 Kodi banja lomwe akuchokera mwanayu ndi la mtundu wanji?

1☐ Ayawo
2☐ Alomwe
3☐ Anyanja/Achewa
4☐ Angoni
8☐ Sindikudziwa
9☐ Palibe yankho
0☐ Mtundu wina ____________

2.6 Kodi matendawa anamyamba liti mwanayu? (Makamaka amene mwafikira nawo kunowa?)

1☐ Dzulo
2☐ Lisanafike dzulo koma mkati mwa sabatayi
3☐ Tisadafike sabata yathayi komabe mkati mwa mwezí watha
4☐ Papita mwezi umodzi
8☐ Sindikudziwa
9☐ Palibe yankho

2.7 Kodi chiyambire chaka chino, mwanayu adabwerako kuno ku Chipatala?

1☐ Inde 8☐ Sindikudziwa

2☐ Ayi (SKIP TO Q. 2.10) 9☐ Palibe yankho

2.8 Kodi mwanayu anabweranso ndi matenda omwewa akudwala lerowa?

1☐ Inde 8☐ Sindikudziwa

2☐ Ayi 9☐ Palibe yankho

2.9 Chiyambire zomwe tikufufuzazi, kodi mwana wanu adasankhidwaponso?

1☐ Inde 8☐ Sindikudziwa

2☐ Ayi 9☐ Palibe yankho

2.10 Kodi m'banja la mwanayu, alipo wina amene watsegula m'mimba sabata yathayi? (kusowa kwa madzi mthupi mwake, kutsegula m'mimba kwambiri kapena chimbudzi cha magazi)

1☐ Inde 8☐ Sindikudziwa

2☐ Ayi 9☐ Palibe yankho

2.11 Kodi banja la mwanayu limatunga kuti madzi awo akumwa?

1☐ Ku mpopi 6☐ Madzi amvula

2☐ Ku dirawo 7☐ Kasupe wosamangidwa

3☐ Chitsime chomangidwa 8☐ Sindikudziwa

4☐ Chitsime chosamangidwa 9☐ Palibe yankho

5☐ Kumtsinje 0☐ Malo ena ________________

3.0 Tsopano ndi nthawi yakuti tipangane za tsiku ndiponso nthawi imene mungafune kuti mayi wina akuyendereni kunyumba kwanu ndikukacheza nanu komanso kukufunsani mafunso angapo. Kodi ndi nthawi yanji imene iri yabwino kwa inu imene mukhoza kupezeka pakhomo panu ndikukhala ndi mwayi wakuti mayiyo acheze nanu?

1☐ M'mawa weniweni 4☐ 12 koloko itangopitirira

2☐ Chakum'mawa dzuwa litakwerako pang'ono 5☐ Chakumadzulo

3☐ Nthawi itayandikira 12 koloko 6☐ Nthawi iriyonse

3.1 Kodi alipo masiku amene mukudziwa kuti simungapezeke pakhomo sabata ya mawayi?

1 ☐ Lolemba	5 ☐ Lachisanu
2 ☐ Lachiwiri	6 ☐ Loweruka
3 ☐ Lachitatu	7 ☐ Lamulungu/lasabata
4 ☐ Lachinayi	8 ☐ Palibe ayi

Ngati ziri choncho ndiye kuti mayi uja ndanena adzafika kudzakuchezerani pa tsiku la .... nthawi ya .... monga mwanena. Koma ndikufuna tsopano kudziwa kumene mumakhala.

Mudzi wa ______________________________

Mfumu yaikulu ______________________________

Kodi ndikhoza kuyenda bwanji kuti ndifike kunyumba kwanu? Mayendedwe ake ndiwotani kuti munthu akhoze kufika kwanu? (Midzi imene ayandikana nayo, mishoni kapena sukulu, masitolo, etc.)

____

____

____

____

____

NOW ASK THE PARENT (OR OTHER ADULT) IF YOU MAY TAKE SOME MEASUREMENTS OF THE CHILD

4.1 Weight: ____________________ (record in kilograms) ☐☐☐

4.2 Height: ____________________ (record in centimeters) ☐☐☐

IF THE CHILD'S MOTHER IS NOT THE PERSON YOU HAVE TALKED TO PLEASE FIND OUT THE MOTHER'S NAME ______________________________

Zikomo kwambiri chifukwa cha thandizo lanu. Isi ndizimene ndimafuna kudziwa kuchokera kwa inu. Nanga muli ndi mafunso ena aliwonse? Muli ndi mwayi wakufunsa mafunso anu tsopano.

I.D. Number

HOUSEHOLD SURVEY

Mother's name ____________________

Child's name ____________________

Person who brought the child to clinic (if different from Mother) ____________________

Village ____________________

Traditional Authority ____________________

Location of House ____________________

____

____

____

____

Interview Time/Day ____________________

VISIT RECORD

Interviewer	Visit Number	Date	Time	Result (use Code)	Return for Interview	
					Date	Time

Result Code:
1 - Interview completed
2 - Interview partly completed, appointment made for continuation
3 - No one at home
4 - Appropriate respondent not at home; appointment made for interview later.
5 - Refusal
6 - Other (specify) ____________________

____

Review by Supervisor: ____________________
(Signature)

I am .... from the Ministry of Health. I would like to ask you a few questions about your children and your family. The government wants to develop this country by bringing up our children well so that they will be better leaders for the future. Therefore, I have come here to learn from you how you care for your children under five years of age. By so doing, the government will know how they can reduce the problems people are facing here. You have been chosen because your child came to the Clinic this week. If you have problems in answering my questions, please let me know.

1 FETCHING WATER

1.1 Where do you fetch your drinking water?

- 1 ☐ Pipe
- 2 ☐ Borehole
- 3 ☐ Protected well
- 4 ☐ Unprotected well
- 5 ☐ River
- 6 ☐ Rainwater
- 7 ☐ Unprotected spring
- 8 ☐ Don't know (if this response, then talk to someone else)
- 9 ☐ No response
- 0 ☐ Other ______________

1.2 Does your child, who came to the Clinic last week, usually drink water from other sources?

- 1 ☐ Protected places (pipe, borehole, protected well)
- 2 ☐ Unprotected places (unprotected well, rainwater, unprotected spring)
- 3 ☐ Both types
- 8 ☐ Don't know
- 9 ☐ No response
- 0 ☐ Other ______________

1.3 Do you know what water the child drank the week before he became sick?

- 1 ☐ Protected places (pipe, borehole, protected well)
- 2 ☐ Unprotected places (unprotected well, rainwater, unprotected spring)
- 3 ☐ Both types
- 8 ☐ Don't know
- 9 ☐ No response
- 0 ☐ Other ______________

1.4 Where do you fetch water for cooking?

1☐ Pipe
2☐ Borehole
3☐ Protected well
4☐ Unprotected well
5☐ River
6☐ Rainwater
7☐ Unprotected spring
8☐ Don't know
9☐ No response
0☐ Other ________________

☐

1.5 Where do you fetch water for cleaning/washing food?

1☐ Pipe
2☐ Borehole
3☐ Protected well
4☐ Unprotected well
5☐ River
6☐ Rainwater
7☐ Unprotected spring
8☐ Don't know
9☐ No response
0☐ Other ________________

☐

1.6 Where do you fetch water for washing your utensils?

1☐ Pipe
2☐ Borehole
3☐ Protected well
4☐ Unprotected well
5☐ River
6☐ Rainwater
7☐ Unprotected spring
8☐ Don't know
9☐ No response
0☐ Other ________________

☐

1.7 Which water do you use for washing clothes?

1☐ Pipe
2☐ Borehole
3☐ Protected well
4☐ Unprotected well
5☐ River
6☐ Rainwater
7☐ Unprotected spring
8☐ Don't know
9☐ No response
0☐ Other ________________

☐

1.8 How many times do you bathe your child each week, each day?

1☐ More than once per day
2☐ Once per day
3☐ Every other day
4☐ Twice/week
8☐ Don't know
9☐ No response
0☐ Other ________________

☐

1.9 Where do you fetch the water to give the child a bath?

1 ☐ Pipe	6 ☐ Rainwater
2 ☐ Borehole	7 ☐ Unprotected spring
3 ☐ Protected well	8 ☐ Don't know
4 ☐ Unprotected well	9 ☐ No response
5 ☐ River	0 ☐ Other ______________

---

2 WATER QUANTITY

2.1 Who fetches the water you use at this house? And how old is she/he?

Age	Male	Female	Total
5-9			
10-14			
15++			

2.2 Is water usually brought to the house for the following uses?

	Yes	No	Don't know	No response
Men bathing	☐ 1	☐ 2	☐ 8	☐ 9
Women bathing	☐ 1	☐ 2	☐ 8	☐ 9
Washing clothes	☐ 1	☐ 2	☐ 8	☐ 9
Watering animals	☐ 1	☐ 2	☐ 8	☐ 9
Smearing floors	☐ 1	☐ 2	☐ 8	☐ 9
Making bricks	☐ 1	☐ 2	☐ 8	☐ 9
Other uses	☐ 1	☐ 2	☐ 8	☐ 9

Write other uses here ______________________________

3 HEALTH EDUCATION

3.1 Do you go to the Under-Five clinic with your child? ☐

1 ☐ Yes   9 ☐ No response

2 ☐ No (SKIP TO Q. 3.3)

3.2 Will you please show me the clinic card for the child you brought to the clinic? How many times have you been to the Under-Five clinic with the child?

Number ______________________ ☐☐

88 ☐ Don't know   99 ☐ No response

(SOURCE OF INFORMATION) ☐

1 ☐ Mother's estimate   2 ☐ Clinic Card

3.3 How many meetings conducted by the Health Instructors have you attended since the last harvest? ☐

0 ☐ 0   3 ☐ >2

1 ☐ 1   8 ☐ Don't know

2 ☐ 2   9 ☐ No response

3.4 How many times have the Health Instructors visited you? ☐

0 ☐ 0   3 ☐ >2

1 ☐ 1   8 ☐ Don't know

2 ☐ 2   9 ☐ No response

3.5 Does your child ☐

1 ☐ breastfeed?   8 ☐ Don't know

2 ☐ breastfeed and eat other things?   9 ☐ No response

3 ☐ stopped breastfeeding?

4 HYGIENE

4.1 Will you show me the jar/pot you use to keep drinking water?

OBSERVE

IS THE JAR
- 1 ☐ Inside the house
- 2 ☐ Outside the house
- 8 ☐ Don't know

IS THE JAR
- 1 ☐ Covered
- 2 ☐ Not covered
- 8 ☐ Don't know

4.2 Will you show me the cup you use to fetch water from the jar?

OBSERVE
- 1 ☐ It has a handle
- 2 ☐ It has no handle
- 8 ☐ Don't know

4.3 Do you use the same jar for fetching and storing water?
- 1 ☐ Yes
- 2 ☐ No
- 8 ☐ Don't know
- 9 ☐ No response

4.4 Could you show me the place where you prepare your meals?

OBSERVE
- 1 ☐ Filthy
- 2 ☐ Clean but disorderly
- 3 ☐ Clean and orderly
- 0 ☐ Other ______________

WHERE DO THEY PREPARE FOOD:
- 1 ☐ Kitchen (separate building)
- 2 ☐ On porch
- 3 ☐ Grasshouse

4.5 Would you please show me where you dry your kitchenware (plates, pots, etc.)
- 1 ☐ Dish rack
- 2 ☐ On the grainery
- 3 ☐ On grass/ground
- 4 ☐ On flowers
- 5 ☐ In a basket
- 8 ☐ Don't know
- 9 ☐ No response
- 0 ☐ Other ______________

4.6 Would you show me where you dispose of your rubbish?

1 ☐ Rubbish pit
2 ☐ Scattered everywhere
3 ☐ Burnt
4 ☐ Buried
5 ☐ Used as manure/in garden
8 ☐ Don't know
9 ☐ No response
0 ☐ Other ______________

---

5 SOCIO-ECONOMIC

5.1 Where is the father of this child?

1 ☐ Here
2 ☐ Not here
9 ☐ No response

5.2 Whom do you ask when you want to take the child to the clinic?

1 ☐ Father
2 ☐ Child's uncle
3 ☐ Mother's uncle
4 ☐ No one
5 ☐ Grandmother or grandfather
9 ☐ No response
0 ☐ Other ______________

5.3 What job is ...... (answer from Q. 5.2) doing?

1 ☐ Subsistence farmer
2 ☐ Other farmer
3 ☐ Businessman
4 ☐ Teacher
5 ☐ Fisherman
6 ☐ Laborer
7 ☐ Carpenter
8 ☐ Tailor
9 ☐ No response
0 ☐ Other ______________

5.4 Apart from maize, what other important crop do you grow?

____

5.5 What religion is the family?

1 ☐ Catholic
2 ☐ Church of Central Africa Presbyterian
3 ☐ Baptist
4 ☐ Church of Christ
5 ☐ Zambezi Industrial Mission
6 ☐ Anglican
8 ☐ Islam
9 ☐ No response
0 ☐ Other ____________

5.6 Has the mother of the child ever been to school?

1 ☐ Never
2 ☐ Standard 1-4
3 ☐ Standard 5-8
4 ☐ Form 1-2
5 ☐ Form 3-4
7 ☐ Above Form 4
8 ☐ Don't know
9 ☐ No response

5.7 Is the father also educated?

1 ☐ None
2 ☐ Standard 1-4
3 ☐ Standard 5-8
4 ☐ Form 1-2
5 ☐ Form 3-4
7 ☐ Above Form 4
8 ☐ Don't know
9 ☐ No response
0 ☐ Question not asked because father lives elsewhere

5.8 How many people use water from this house usually?
(RECORD HOW MANY IN EACH AGE CATEGORY)

0-4 ____________

5-9 ____________

10-14 ____________

15-25 ____________

26 and older ____________

5.9 How old are you? ____________

5.10 OBSERVE IF THE HOUSE HAS:

	Yes	No	Don't know
Iron sheets	1 ☐	2 ☐	8 ☐
Cement floor	1 ☐	2 ☐	8 ☐
Mud floor	1 ☐	2 ☐	8 ☐
Burnt bricks	1 ☐	2 ☐	8 ☐
Mud bricks	1 ☐	2 ☐	8 ☐
Of mud	1 ☐	2 ☐	8 ☐
Glass windows	1 ☐	2 ☐	8 ☐
Other windows	1 ☐	2 ☐	8 ☐
Bath house	1 ☐	2 ☐	8 ☐

5.11 Would you please show me what you use to fetch water?

Type				
Height measure to water level				
Top circumference at water level				
Bottom circumference				
Widest circumference for clay pots				
Number fetched each day				

Quantity of water fetched (liters) ______________________
(Supervisor will determine this)

5.12 Do you have a latrine?

1 ☐ Yes (if so, ask to see it)

2 ☐ No

5.13 OBSERVE HOW THE LATRINE IS:

	Yes	No	Don't know
If the walls are destroyed	☐ 1	☐ 2	☐ 8
If the floor is well smeared	☐ 1	☐ 2	☐ 8
If the roof is well thatched	☐ 1	☐ 2	☐ 8
If the hole is covered	☐ 1	☐ 2	☐ 8
If there are flies	☐ 1	☐ 2	☐ 8

If possible, how many flies ____________________

If the path is well worn	☐ 1	☐ 2	☐ 8

BEFORE YOU LEAVE:

1) TAKE A WATER SAMPLE FROM THE DRINKING WATER POT.

NUMBER THE BAG WITH ID NUMBER.

2) WALK TO THE WATER SOURCE AND RECORD THE NUMBER OF PACES ____________________________

THANK THE MOTHER FOR HER HELP !!!

Distance from house to health health clinic:

____

(Supervisor will determine this)

DRINKING WATER:

Conductivity ______________________________

Fecal coliform ______________________________

Fecal strep ______________________________

WATER SOURCE:

Fecal coliform ______________________________

Fecal strep ______________________________

I.D. Number

HOUSEHOLD SURVEY

Mother's name ____________________

Child's name ____________________

Person who brought the child to clinic (if different from Mother) ____________________

Village ____________________

Traditional Authority ____________________

Location of House ____________________

____

____

____

____

Interview Time/Day ____________________

VISIT RECORD

Interviewer	Visit Number	Date	Time	Result (use Code)	Return for Interview Date	Return for Interview Time

Result Code:
1 - Interview completed
2 - Interview partly completed, appointment made for continuation
3 - No one at home
4 - Appropriate respondent not at home; appointment made for interview later.
5 - Refusal
6 - Other (specify) ____________________

____

Review by Supervisor: ____________________
(Signature)

Ine ndine .... wochokera ku Unduna wa za Umoyo. Ndifuna kukufunsani mafunso pang'ono okhudza ana anu ndi banja lanu. Boma likufuna kutukula dziko lino polera ana athu bwino kuti adzakhale atsogoleri abwino amtsogolo. Choncho ndabwera pano kuti mundiuze za m'mene mumalerera ana anu osapitirira zaka zisanu.

Pakuchita izi Boma lingathe kudziwa bwion m'mene angachepetsere mabvuto omwe anthu akukumana nawo. Inu mwasankhidwa chifukwa mwana wanu anabwera ku Chipatala mulungu omwe uno. Koma ngati muli ndi bvuto poyankha mafunso amenewa chonde mundidziwitse.

I KUTUNGA MADZI

1.1 Kodi madzi anu akumwa mumatunga kuti kawirikawiri?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa (ngati ayankha mhoncho lankhulani ndi munthu wina)
4	Chitsime chosamangidwa		
5	Kumtsinje	9	Kusayankha
		0	Malo ena _______________

1.2 Kodi mwana wanu amene anabwera ku Chipatala mulungu watha amamwako madzi otungidwa mbali zina kawirirkawiri?

1 Malo otetezedwa (mpopi, dirawo, chitsime chomangidwa)

2 Malo osatetezedwa (Chitsime chosamangidwa, madzi amvula kasupe wosamangidwa)

3	Njira zonse ziwiri	9	Palibe yankho
8	Sindikudziwa	0	Malo ena _______________

1.3 Kodi mungathe kudziwa madzi womwe mwanayu anamwapo mulungu umodzi asanayambe kudwala?

1 Malo otetezedwa (mpopi, dirawo, chitsime chomangidwa)

2 Malo osatetezedwa (Chitsime chosamangidwa, madzi amvula kasupe wosamangidwa)

3	Njira zonse ziwiri	9	Palibe yankho
8	Sindikudziwa	0	Malo ena _______________

1.4 Kodi madzi anu ophikira chakudya mumatunga kuti?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa
4	Chitsime chosamangidwa	9	Palibe yankho
5	Kumtsinje	0	Malo ena ____________

1.5 Kodi madzi anu otsukira zakudya mumatunga kuti?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa
4	Chitsime chosamangidwa	9	Palibe yankho
5	Kumtsinje	0	Malo ena ____________

1.6 Kodi madzi anu otsukira ziwiya zanu mumatunga kuti?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa
4	Chitsime chosamangidwa	9	Palibe yankho
5	Kumtsinje	0	Malo ena ____________

1.7 Ndi madzi ati amwe mumachapira zobvala zanu?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa
4	Chitsime chosamangidwa	9	Palibe yankho
5	Kumtsinje	0	Malo ena ____________

1.8 Mwana wanu mumam'sambitsa kangati pa mulungu, nanga pa tsiku?

1	Kupitirira	8	Sindikudziwa
2	Kamodzi pa tsiku	9	Palibe yankho
3	Kudumphitsa tsiku limodzi	0	Zifukwa zina ________
4	Kawiri pa mulungu		

1.9 Mumatunga kuti madzi omwe mumamsambitsa mwanayu?

1	Mpopi	6	Madzi amvula
2	Dirawo	7	Kasupe wosamangidwa
3	Chitsime chomangidwa	8	Sindikudziwa
4	Chitsime chosamangidwa	9	Palibe yankho
5	Kumtsinje	0	Malo ena ______________

---

2 WATER QUANTITY

2.1 Kodi amene amakatunga madzi amene mumagwiritsira ntchito pa nyumba pano ndani? Nanga ali ndi zaka zingati?

Age	Mwamuna	Mkazi	Total
5-9			
10-14			
15++			

2.2 Kodi nthawi zonse madzi amatungidwa kugwiritsa ntchito izi?

	Inde	Ayi	Sindikudziwa	Palibe yankho
Osamba amuna	1	2	8	9
Osamba azimayi	1	2	8	9
Kuchapira zobvala	1	2	8	9
Kumwetsa ziweto	1	2	8	9
Kuzira	1	2	8	9
Kuumba njerwa	1	2	8	9
Ntchito zina	1	2	8	9

Lembani ntchito zina ________________________________

3 HEALTH EDUCATION

3.1 Kodi mwana wanu mumapita naye ku sikelo?

1 Inde | 9 Palibe yankho

2 Ayi (SKIP TO Q. 3.3)

3.2 Mungandionetse kadi ya ku sikelo ya mwana amene munabwera naye ku chipatala. Ndi kangati mwana ameneyu wakhala akupita ku sikelo?

Number ______________________________

88 Sindikudziwa | 99 Palibe yankho

(SOURCE OF INFORMATION)

1 Mother's estimate | 2 Clinic Card

3.3 Ndi misonkhano ingati imene yapangidwa ndi alangizi a za umoyo yomwe mwakhala mukupitako chikololere?

0 0 | 3 >2

1 1 | 8 Sindikudziwa

2 2 | 9 Palibe yankho

3.4 Ndi kangati akuyenderani alangizi aza umoyo chikololere?

0 0 | 3 >2

1 1 | 8 Sindikudziwa

2 2 | 9 Palibe yankho

3.5 Kodi mwanayu

1 amayamwa | 8 Sindikudziwa

2 amayamwa ndipo amadya zakudya zina | 9 Palibe yankho

3 Simumamuyamwitsa

4 HYGIENE

4.1 Mungandionetse mtsuko momwe mumasungira madzi akumwa?

KUYANG'ANITSITSA

CHOTUNGIRACHO	1	Chiri mkati mwa nyumba
	2	Chiri panja
	8	Sindikudziwa
NANGA CHOTUNGIRACHO NDI	1	Chobvindikira
	2	Chosabvindikira
	8	Sindikudziwa

4.2 Mungandionetse chikho chimene mumagwiritsa ntchito potungira madzi mumtsuko?

KUYANG'ANITSITSA	1	Chiri ndi chogwirira
	2	Chiri be chogwirira
	8	Sindikudziwa

4.3 Kodi mumagwiritsa ntchito chotungira chimodzi chomwecho potungira ndi kusungira madzi?

1 Inde

2 Ayi

8 Sindikudziwa

9 Palibe yankho

4.4 Mungandilole kuti ndione malo amene mumakonzera chakudya?

KUYANG'ANITSITSA

1 Paumve posasamalika

2 Osamalika koma osalongeza bwino

3 Mosamalika ndi molongeza bweno

0 Malo ena ______________

AMAPHIKIRA KUTI:	1	Khitchini
	2	Khonde
	3	Khumbi/Chisakasa

4.5 Mungandionetse kumene mumayanika ziwiya zanu (monga mbale, makapu, mapoto ndi zina)

1	Pa Thandala	5	Mudengu
2	Pa nkhokwe	8	Sindikudziwa
3	Pa kapinga/pansi	9	Palibe yankho
4	Pa maluwa	0	Malo ena___________

4.6 Mungandionetse komwe mumataya zinyalala?

1	Dzenje	5	Ndowe zakumunda
2	kutaya paliponse	8	Sindikudziwa
3	amaunjika nkutentha	9	Palibe yankho
4	amazikwirira	0	Malo ena___________

---

5 SOCIO-ECONOMIC

5.1 Kodi bambo wa mwanayu ali kuti?

1	Alipo	9	Palibe yankho
2	Palibe		

5.2 Mumakawauza ndani mukafuna kutengera mwana ku chipatala kapena kulikonse koti angapeze chithandizo cha mankhwala?

1	Bambo	4	Palibe
2	Malume (wa mwana)	9	Palibe yankho
3	Malume (wamayi)	0	Ena_______________

5.3 Kodi a ....(onani yankho la 5.2) amagwira ntchito yanji?

1	Amalima zakuti tizidya	6	Ntchito ya ulebala
2	Zaulimi (Uchikumbi)	7	Ukalipentala
3	Bizinesi (geni)	8	Utelala
4	Aphunzitsi	9	Palibe yankho
5	Asodzi a nsomba	0	Ntchito zina________

5.4 Kupatula chimanga, ndi mbeu iti ina imene mumalima yofunikira?
____

5.5 Kodi banjalo ndi lachipembedzo chanji?

1	Katolika	5	ZIM
2	CCAP	6	Anglican
3	Baptist	9	Palibe yankho
4	Mpingo wa Kristu	0	Zipembedzo zina ____

5.6 Kodi mayi ake a mwanayu adapitapo ku sukulu?

1	Osaphunzira	5	Form 3-4
2	Std 1-4	7	Kuposera Form 4
3	Std 5-8	8	Sindikudziwa
4	Form 1-2	9	Palibe yankho

5.7 Kodi bambo wa banjalo ndi wophunzira?

1	Osaphunzira	7	Kuposera Form 4
2	Std 1-4	8	Sindikudziwa
3	Std 5-8	9	Palibe yankho
4	Form 1-2	0	Chosafunika kufunsa
5	Form 3-4		

5.8 Kodi ndi angati amene amagwiritsa ntchito madzi a mnyumba muno kawirikawiri? (RECORD HOW MANY IN EACH AGE CATEGORY)

0-4______________________________

5-9______________________________

10-14______________________________

15-25______________________________

26 kupita mtsogolo______________________________

5.9 Nanga inu mayi muli ndi zaka zingati?________________________

5.10 YANG'ANANI NGATI NYUMBAYI IRI NDI:

	Inde	ayi	sindikudziwa
Malata	1	2	8
Ya sementi	1	2	8
Ndi yozira	1	2	8
Yanjerwa zowocha	1	2	8
Ya zidina	1	2	8
Ya dothi	1	2	8
Ya magalasi	1	2	8
Mawindo ena	1	2	8
Bafa	1	2	8

5.11 Kodi mungandilole kuti ndione zimene mumagwiritsa ntchito potunga madzi?

ZOTUNGIRA

Type				
Height measure to water level				
Top circumference at water level				
Bottom circumference				
Widest circumference for clay pots				
Number fetched each day				

Quantity of water fetched (liters) ______________________

(Supervisor will determine this)

5.12 Kodi muli ndi chimbudzi?

1 Inde (ngati chilipo apempheni kuti muchione)

2 Ayi

5.13 YANG'ANANI M'MENE CHIMBUDZI CHIRI

	Inde	ayi	sindikudziwa
Ngati makoma ali ogamuka	1	2	8
Ngati pansi palipozira	1	2	8
Ngati denga lirilofoleledwa	1	2	8
Ngati pachibowo pali povindikira	1	2	8
Ngati muli ntchenche ndipo	1	2	8
Pafupifupi zingati ________________			
Ngati njira yakuchimbudzi imapitidwa	1	2	8

BEFORE YOU LEAVE:

1) TAKE A WATER SAMPLE FROM THE DRINKING WATER POT.

<u>NUMBER THE BAG WITH ID NUMBER.</u>

2) WALK TO THE WATER SOURCE AND RECORD THE NUMBER OF PACES ________________________

THANK THE MOTHER FOR HER HELP !!!

Distance from house to health health clinic:

____

(Supervisor will determine this)

DRINKING WATER:

Conductivity ______________________________

Fecal coliform ______________________________

Fecal strep ______________________________

WATER SOURCE:

Fecal coliform ______________________________

Fecal strep ______________________________

METHODS OF ANALYSIS OF EPIDEMIOLOGIC DATA

The strategy used in analyzing the case-control data had two steps. The first concerned the initial variable specification, and the second was the mathematical modeling which led to an estimate of the risk odds ratio.

I. Initial Variable Specification

Our interest is predicting the probability of a young child developing severe diarrhea. From theory and previous research, we know that contracting diarrhea is a function of many things. This can be generally expressed:

Pr(Diarrhea) = fxn (nutritional status, child's age, income, environmental conditions - water, latrine, hygiene - mother's education, breastfeeding)

Specifically, this study is interested in quantifying the effect of water supplies on the risk of diarrhea. Still the other factors (risk factors which are extraneous variables) must be considered in the model since they can affect the relationship being studied. Variables which should not be in the model are those which are intervening variables (i.e., variables related to the disease only because of exposure) and endogenous variables (i.e., variables which may themselves be a function of the disease). Nutritional status is an example of an endogenous variable. Although current nutritional status affects susceptibility to diseases, it is a direct consequence of previous disease episodes. This correlation between disease and nutritional status leads to bias in the model if nutritional status is specified as an "independent variable." One way around this is to include an estimate of nutritional status in the model, an estimate based upon regression of nutritional status on its determinants other than disease, such as child's age, income, environmental conditions, breastfeeding, etc. (Schultz, 1984). This 2 stage process would first estimate nutritional status and then include that estimate in the disease model. That however, will result in duplicity of variable specification since it is the same set of independent variables which will be in both models. Since the objective here is not to judge the effect of nutritional status *per se*, but the effect of water supplies, then the estimate of nutritional status need not be included in the final disease model. Those variable which operate through nutritional status will be included in the model, however. Thus, even though there is evidence of nutritional difference between cases and controls in the weight for height index, it would be erroneous to include such a variable in the model estimating the probability of diarrhea.

Based upon the general diarrhea function specified earlier, the variables selected for inclusion in the model (based on theory) are:

age	water source (exposure variable)
occupation of household head	latrine
mother's education	dish rack
clinic where recruited	number of visits to under-5 clinic per age in months

Water quantity was not selected for this analysis since the estimates were considered unreliable. Surrogate variables were used where there was no direct measurement, e.g. occupation is used as an indication of income, as is the clinic of recruitment since two clinics were pay-for-treatment clinics. Whether the family had a dish rack is a measure of health education since that is one of the goals of the health education program. Attendance at the well-baby clinic (free) is a measure of the mother's level of care and attention to the child.

Three variables must be in the model, not because they are risk factors for the disease, but because they will introduce bias in the risk odds ratio estimate if not controlled for. These variables are time of recruitment into the study, clinic of recruitment and distance to the clinic. The first two, time and clinic of recruitment, must be controlled for because the "exposure" to piped water varied with both. Each clinic served a population which had a certain availability of piped water. For Pirimiti, it was about 38% of the clinic users that had piped water. For Sitima it was 85%. Due to several major pipeline breaks, the percentage of people served by piped water also decreased during certain periods. There were 5 periods over the 4 month recruitment time when piped water availability distinctly changed.

The third variable which could introduce bias if not controlled for is the distance from home to clinic. The availability of piped water is somewhat related to clinic location in that typically the areas closer to the clinics had piped water whereas those distant did not. If the propensity to use the clinic differed for children with diarrhea and children with the control diseases then there could be a selection-induced bias towards a water supply for each group related to their distance from the clinic. If the distance distribution is the same for cases as for controls for each clinic, then distance need not be in the model (World Health Organization, 1985). However distance distribution did vary between the case and control groups for each clinic. Thus distance must be controlled to eliminate distance related bias.

So the specification of variables to be in the model was:

water source	age
latrine	occupation
mother's education	clinic of recruitment
breastfeeding status	time period of recruitment
no. under-5 clinic visits	distance to clinic
dish rack	

The mathematical form and categories of these variables are shown in Table 1. Data were collected on other variables such as child's sex, religion of family, size of family, water storage habits, and father's

Table 1

Variables in Model

Variable	Type
1. Water-Latrine combination, 4 categories: Piped Water-Latrine; Unprotected Water-Latrine; Piped Water-No Latrine; Unprotected Water-No Latrine	Dummy
2. Mother's Education: None, Some	Dummy
3. Breastfeeding Status: Breastfed Only; Breastfed + Supplements; Not Breastfed	Dummy
4. Number Under-Five Clinic Visits per Age in Months	continuous
5. Dish Rack: Have dish rack, no dish rack	dichotomous
6. Age in months	continuous
7. Occupation, 3 categories:	
1) subsistence farmers, fishermen; 2) carpenter, laborer, other farmer; 3) businessman, teacher, tailor, other	dummy
8. Clinic: Pirimiti, Sitima, Chamba	dummy
9. Time or Recruitment, 5 periods: 1) days 1-36; 2) days 37-51; 3) days 52-78; 4) days 79-108; 5 days 109-121	dummy
10.Distance to clinic	continuous
11.Interaction terms: Cross Products of Water-Latrine Variable and another variable	

education (see Annex B1). These variables were not included in the model because it was judged that either there was no scientific basis for their inclusion (e.g. sex, religion), that the particular variable exhibited strong correlation with another variable already in the model (father's education and mother's education) or that the distribution of the variable was the same among exposure categories of cases and controls and mathematically would not need to be in the model comparing relative risks between cases and controls. The model should be as simple as possible in structure yet consistent with the observed data.

The manner in which these variables are specified in the model is important because their effects on the overall estimate of the risk odds ratio can take several forms. First they can act as "effect modifiers" and work with the exposure variable (water source) to produce an effect greater (or less) than that expected by their separate actions. This is observed statistically as nonuniformity of odds ratios over strata, when the data are stratified on the variable of interest. This variable is known as an interaction term if such nonuniformity of the odds ratio exists. The interpretation of such nonuniformity is that the exposure and interaction variables are exhibiting different effects on the disease outcome in these different groups (strata) of the population. For the present analysis, three variables were judged as probable effect modifiers-latrine, breastfeeding and mother's education.

The second effect extraneous risk factors can exhibit is that of confounding, a bias in the odds ratio resulting from lack of consideration of these variables. By "controlling" for these confounding risk factors, bias will be reduced or completely eliminated when estimating the true exposure-disease relationship. There may be scientific reason to consider a certain risk factor as a confounder, but there may not be data-based justification to include it in the model as such. An example would be age, which is known to have an effect on susceptibility to diarrhea. If the control group selected had a different age distribution than the case (diarrhea) group, age would need to be controlled as a confounder. If the controls were age-matched to the cases, there would be no need to control for age as a confounder. All the variables selected for inclusion in the model were considered potential confounders and were treated as such.

II. Logistic Regression Analysis

Multivariate analysis is used to interpret the individual and joint effects of variables on the risk of disease. One such type of multivariate analysis is the logistic regression model. The logistic model specifies that the probability of disease depends on a set of variables $x_1, x_2, \ldots, x_p$ in the following way:

$$P(x) = P(D=1 \mid x_1, x_2, \ldots, x_p)$$

$$= \{1 + \exp[-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p)]\}^{-1} \quad (1)$$

The variable D denotes either the presence (D=1) of absence (D=0) of disease and x denotes the set of p variables, $x = (x_1, x_2, \ldots, x_p)$ which represents potential risk factors, confounding variables, and interactions of interest. This logistic function P(x) varies from 0 to 1 and thus can be used to model the risk of disease development. The odds of an individual developing disease is the probability of being diseased relative to the probability of not being diseased and can be shown to be mathematically equivalent to:

$$\frac{P(x)}{1-P(x)} = \exp\ [\beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p]$$

If one wishes to compare the relative odds of disease for individuals with different values of the x variables, say x* and x, then the risk odds ratio is:

$$ROR = \frac{P(x^*)/[1-P(x^*)]}{P(x)/[1-P(x)]} = \frac{\exp\ [\beta_0 + \beta_1 x_1^* + \beta_2 x_2^* + \ldots + \beta_p x_p^*]}{\exp\ [\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p]}$$

$$ROR = \exp\ [\sum_{i=1}^{p} \beta_i\ (x_i^* - x_i)] \qquad (2)$$

The risk odds ratio depends only on those factors for which two individuals <u>differ</u>. If the value $x_2^* = x_2$ then the term $\beta_2(x_2^* - x_2)$ is zero. Thus if one of the variables, say x_1, represents an exposure of particular interest, the disease-exposure odds ratio for two individuals who are equal on the remaining variables is simply $ROR = \exp\{\beta_1 (x_1^* - x_1)\}$. If this x_1 variable is dichotomous and coded 1=present and 0=absent then $ROR = \exp[\beta_1]$.

Thus when using the logistic model to evaluate the risk of disease with reference to a particular exposure of interest, all confounding and interaction terms are part of the disease probability equation (1), and are used when estimating the parameters (β's). Once the set of β's has been estimated, however, only those terms which include the exposure of interest will be part of the risk odds ratio (2) since other variables will be equal and fall out of the equation. This allows evaluation of the effect on the ROR of a single variable, such as water source, while making allowances for the effects of other related variables.

Table 1

Risk Odds Ratio Comparing No Latrine to Latrine, While Using Unprotected Water Supply

		ROR	95% Confidence Interval
No Education:			
	Breastfed Only	1.48	0.28-7.91
	Breastfed + Supplements	1.20	0.69-2.11
	Not Breastfed	0.85	0.32-2.29
Standard 1-4 and Higher:			
	Breastfed Only	0.72	0.14-3.64
	Breastfed + Supplements	0.58	0.32-1.05
	Not Breastfed	0.41	0.15-1.17

Table 2

Risk Odds Ratio Comparing Use of Unprotected Water Supply to Piped Water, When There Is No Latrine

		ROR	95% Confidence Interval
No Education:			
	Breastfed Only	1.18	0.20-6.82
	Breastfed + Supplements	0.68	0.36-1.27
	Not Breastfed	0.36	0.10-1.30
Standard 1-4 and Higher:			
	Breastfed Only	0.54	0.08-3.72
	Breastfed + Supplements	0.31	0.14-0.71
	Not Breastfed	0.16	0.04-0.62

Table 3

Risk Odds Ratio Comparing Use of Unprotected Water Supply to Piped Water, When There is A Latrine

	ROR	95% Confidence Interval
No Education:		
Breastfed Only	3.87	0.28-54.47
Breastfed + Supplements	1.07	0.51-2.27
Not Breastfed	0.82	0.26-2.55
Standard 1-4 and Higher:		
Breastfed Only	4.05	0.32-51.06
Breastfed + Supplements	1.12	0.58-2.18
Not Breastfed	0.86	0.27-2.73

Table 4

Risk Odds Ratio Comparing No Latrine to Latrine When Piped Water is Used

	ROR	95% Confidence Interval
No Education:		
Breastfed Only	4.85	0.33-70.82
Breastfed + Supplements	1.90	0.88-4.09
Not Breastfed	1.93	0.49-7.61
Standard 1-4 and Higher:		
Breastfed Only	5.40	0.35-83.64
Breastfed + Supplements	2.11	0.90-4.99
Not Breastfed	2.15	0.53-8.77

Table 5

Risk Odds Ratio Comparing Use of Unprotected Water Supply and No Latrine to Use of Piped Water and Latrine

	ROR	95% Confidence Interval
No Education:		
Breastfed Only	5.72	0.47-70.22
Breastfed + Supplements	1.29	0.62-2.67
Not Breastfed	0.70	0.24-2.05
Standard 1-4 and Higher:		
Breastfed Only	2.90	0.25-33.39
Breastfed + Supplements	0.66	0.33-1.30
Not Breastfed	0.35	0.11-1.15