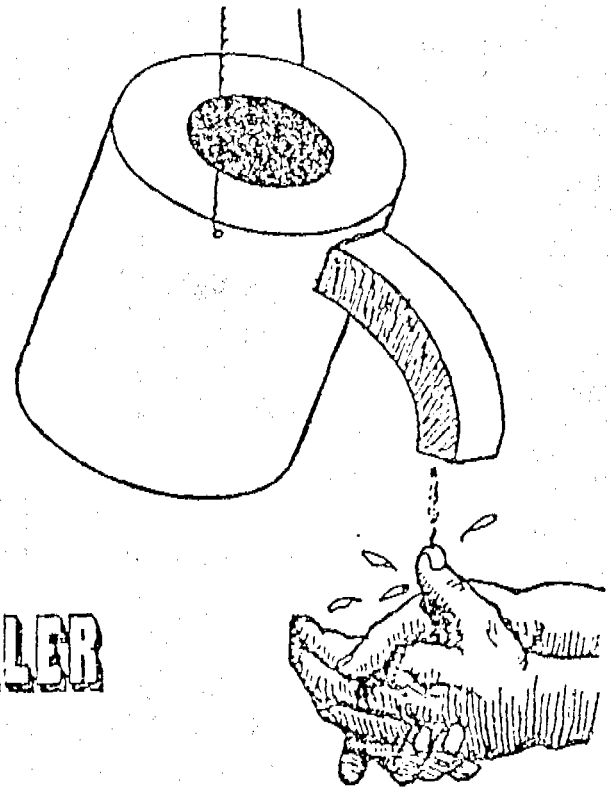
TRADITIONAL HANDWASHING IN ZIMBABWE AND THE USE OF THE MUKOMBE

: MICROBIOLOGICAL AND BEHAVIOURAL ASPECTS



EVA KALTENTHALER
FELIX CHAWIRA
RICHARD WATERMAN

Blair Research Laboratory
Box 8105
Causeway, Harare

Table of Contents

List of Annexes

Forward

This report describes the the work undertaken by Eva Kaltenthaler, Felix Chawira, Michael Jere and Richard Waterman on the intriguing and little studied subject of hand-washing in the rural family setting. It is a combination of a microbiological and behavioural study and has greatly increased our knowledge of this much discussed subject.

It now becoming more well known that the health of an individual, like that of a community, its not solely reliant on the simple provision of a tap or the use of a safe latrine, but on a number of related factors which might include an adequate diet, the completion of an immunisation programme, protection from vector borne disease, and note that the least, an adequate knowledge of how to be healthy. A healthy home environment, and a good knowledge of personal hygiene are essential requirements, and go hand in hand with an improved standard of living and of education.

People have tried to link improved water supply with improved health have often failed. The reason may be simple enough. The provision of an improved supply alone can never be enough without the education and knowledge to make proper use of the water. It is with this background that the researchers have endeavoured to expand our knowledge of the crucial aspect of personal hygiene, and in this instance, the vital activity of hand-washing.

They have discovered the great variation between families, and in many ways the inadequacy of the traditional hand-washing technique. They have examined the popularity and use of a simple but elegant washing device called a "mukombe" and have proved that in the areas of study it is far more effective at removing faecal bacteria from the hands than the traditional bowl, and for most of its users popular and in regular use. Since adequate hand-washing is a crucial step taken along the road to health, this study comes at a vital time.

I compliment the researchers for the meticulous and enthusiastic way they have conducted this work, and hope that it will spur on continued research in this vital sector. We must thank UNICEF for their financial support and the encouragement of the Director and Staff of the Ministry of Health's Blair Research Laboratory.

Peter Morgan

Medical Research Officer
Blair Research Laboratory

June 1988

Acknowledgments

We would like to thank the following people and institutions for making this project possible:

Blair Research Laboratory, especially Dr. P Taylor Taylor, Dr. P Morgan, Mr Michael Jere and Mr Peter Mazana for their hard work and helpful support throughout the project.

UNICEF for their financial assistance and Mr D Williams for his helpful advice.

Mr P Cross, Ministry of Health, Water and Sanitation Advisor, for help with designing the project methodology particularly the questionnaires.

Dr. M Bourdillion University of Zimbabwe, Sociology Department for assistance with designing the questionnaires and supervising the observational exercises. Also the University of Zimbabwe for providing research assistants to carry out the observational exercises.

Meteorological Office of Zimbabwe

Dr S Spooner for photography

Ministry of Health, Mashonaland East for allowing the project to be carried out in this area.

Frances Cleaver, Ministry of Health, for assisting with the final production of this report.

Eva Kaltenthaler

Felix Chawira

Richard Waterman

Blair Research Laboratory June, 1988

Summary

Diarrhoea continues to be a major health problem among children under 5 in developing countries. As personal hygiene is thought to be an important factor in controlling diarrhoeal diseases, this study explored hand-washing, one of the most important aspects of personal hygiene. The study was carried out on commercial farms, in a rural area and in a peri-urban area in Zimbabwe. It was composed of three major phases to explore and compare:

1. traditional hand-washing
2. hand-washing using soap
3. hand-washing using a mukombe.

In the traditional hand-washing phase of the study the hands of mothers and children in 80 families were examined for the presence of faecal indicator bacteria. Out of the 274 people tested the mean number of faecal coliforms was 56/100ml of water and the mean number of faecal streptococci was 298/100ml of water. Also part of the traditional hand-washing study was a questionnaire in which mothers were asked their feelings about hand-washing, personal and domestic hygiene. Hygiene observations were also made by research assistants. Factors found to be associated with high counts were high relative humidity, living on a commercial farm, and having an infant in the family. Mothers and children 0-5 years had higher counts than children 6-12 years. People involved in outdoor physical activities had higher counts than people involved in other activities. Eight families were observed for three days each to determine what hygiene behaviour actually took place in the home. Families in the rural area tended to wash more frequently than families on the commercial farms.

Another important finding is that only 47% of mothers mentioned disease prevention or hygiene as the reason why hand-washing is important.

For the soap section of the study mothers and children in 39 families were asked to wash their hands with soap. These bacteriological results were compared with those of the traditional hand-washing. Hand-washing with soap appeared to remove significantly more faecal indicator bacteria from the hands than traditional hand-washing without soap.

In the final phase of the study 50 families were given a hand-washing device called a mukombe along with instructions on its use. This mukombe is a modification of the traditional gourd and is made of galvanized metal, holding about 2 litres of water. When the spout is tipped, 200ml of water is released, which is sufficient to wash the hands. Again the microbiological results were compared with those of traditional hand-washing and hand-washing using soap. Washing with the mukombe appeared to remove considerably more bacteria from the hands than the traditional hand-washing method, and slightly less than the method using soap. Approximately 58% of the mukombes appeared to be in regular use, and were well accepted by the families using them.

1 Introduction

1.1. Purpose of the Study

Personal hygiene is thought to be a major factor in the control of diarrhoeal diseases. This study explored the effectiveness of one aspect of personal hygiene, hand-washing, in removing faecal bacteria from the hands. In order to gain information about the various aspects of hand-washing in Zimbabwe, this study was designed to consist of four major objectives. These objectives were:

1) to determine the effectiveness of traditional hand-washing in removing transient faecal bacteria from the hands
2) to determine how soap alters this effectiveness
3) to determine whether or not the mukombe is an effective and efficient hand-washing facility
4) to determine whether or not the mukombe is a culturally acceptable hand-washing facility.

The method for exploring these four objectives consisted of a study divided into three major phases. The first looked at traditional hand-washing, the second at hand-washing with soap and the third at the use of the mukombe.

1.2. Traditional Hand-washing Phase

In the first phase, dealing with traditional hand-washing both microbiological and sociological aspects were explored. Eighty families took part in the study and were chosen from a peri-urban area, a rural area and commercial farms. The sociological part of this first phase included a detailed questionnaire covering personal and domestic hygiene, family size, income and education. This questionnaire was asked of each mother taking part in the study. Eight families of these eighty were chosen to be case studies. Students from the University of Zimbabwe interviewed these families and observed their hygiene behaviour for 2-3 days per family. The purpose in this was to determine what differences if any there were in how mothers responded to the questionnaire and what they actually did concerning hygiene behaviour.

In the microbiological part of this first phase, mothers and all children twelve years and under were asked to wash their hands twice in their usual manner. The purpose of the first hand-washing was to remove bacteria from the hands and the second was to give an indication of the bacteria remaining on the hands after the initial hand-washing. The water from the hand-washings was cultured and examined for the presence of faecal coliforms and faecal streptococci.

1.3 Hand-washing with Soap Phase

In the second phase of the study mothers and children in thirty-nine families randomly chosen from the original eighty were asked to wash their hands with soap and then in plain water. Again the hand-washings were cultured and examined for faecal coliforms and faecal streptococci.

1.4 Hand-washing with Mukombe Phase

For the third phase of the study, dealing with the mukombe, fifty families in the three areas were given a mukombe along with a discussion and demonstration on its use. An information sheet explaining its use was also presented to the family.

After 3½-4 months the families were visited and mothers were asked what they thought of the mukombe in the form of a questionnaire. Observations were made to determine if the mukombes were actually being used. Microbiological tests were also carried out to see if the mukombe was effective in removing faecal coliforms and faecal streptococci from the hands.

In order to determine the effectiveness of the mukombe in removing faecal bacteria from the hands, a sample of water from each mukombe was taken to first determine its bacteriological quality. Mothers were asked to use the mukombe to wash their hands and this water was also collected. The mothers were then asked to wash their hands in sterile distilled water.

1.5 Analysis of Data

Various statistical tests were used to compare the effectiveness of traditional hand-washing with hand-washing using soap and hand-washing using the mukombe. The questionnaires were analysed in order to give insight into hygiene behaviours, possibly associating specific hygiene behaviours and other factors with high bacteriological counts on the hands.

Analysis of the mukombe questionnaire was undertaken in order to get an indication of the cultural acceptability, peoples feelings about it and ways that it could be improved. From the analysis of the data it was hoped that a great deal of information concerning hand-washing in Zimbabwe would be obtained.

2. Background

2.1 Personal Hygiene and Hand-washing

Diarrhoeal diseases continue to be a major health problem in developing countries killing large numbers of children under the age of five. Spread through the faecal-oral route, improved sanitation and water supplies have not necessarily decreased the incidence of these diseases (Koopman, 1978). Other factors besides clean water and adequate sanitation are obviously involved.

Hygiene, both personal and within homes and schools is thought to be a major factor in controlling the spread of diarrhoeal pathogens. One study exploring hygiene took place in Columbia where it was found that diarrhoea was related to school toilet hygiene. Factors taken into consideration when determining the standard of hygiene in schools were: provision of toilet paper, soap and towels, the number of toilets and their condition, the size of the classrooms and the provision of adequate water supplies. In this study if hygiene conditions were improved the incidence of diarrhoeal diseases could be reduced by 44% (Koopman, 1978).

Young children who are at greatest risk from diarrhoeal diseases have particularly poor hygiene practices. There may be some relationship between these poor hygiene practises and their high incidence of diarrhoea. In Zimbabwe 15% of children between the ages of 0-4, who died in hospital died as a result of diarrhoeal diseases (World Bank, 1983).

Of the many aspects of personal hygiene, the one which has been most studied is hand-wahing. The role of hand-washing in the prevention of nosocomial infections was recognized over a century ago (Steere, et al, 1975). Since then, studies have shown that enteric infections in hospitals may be spread via contaminated hands. Studies on hand-washing have also been done in day care centres and other institutions. These studies looked at transient microorganisms. Transient microorganisms are defined as those acquired, which do not survive for long periods of time and do not multiply on the hands, and which can be removed from the hands by washing with soap and water.

Transient microorganisms can be pathogenic. Even a quick hand-washing may be effective in removing significant numbers of transient microorganisms (Sprunt, et al, 1973, Lowbury, et al, 1964).

Two studies outside of the hospital environment show significant reductions in the incidence of diarrhoeal diseases after the introduction of hand-washing programmes. One study took place among urban families in Bangladesh In this study there was a 35 % reduction in the incidence of shigellosis in urban families and a 37% reduction in non-Shigella diarrhoea (Khan, 1972). The second study took place in day care centres in the United States. Here a 48% reduction in diarrhoeal incidence was recorded in children aged 0-71 months (Black, et al, 1981). These findings show that hand-washing may play a significant role in reducing the incidence of diarrhoeal diseases.

A recent study which took place in Bangladesh looked at different hygiene behaviours within families, one of which was hand-washing by mothers before food preparation. In the control group (children without diarrhoea) 82% of mothers washed their hands before food preparation, whereas in the case group (children with diarrhoea) only 53% of mothers were observed to wash their hands before food preparation

This finding was used as part of an educational intervention. As a result of the intervention 49% of mothers washed their hands before food preparation and in the non-intervention areas 33% of mothers washed their hands before food preparation. There was a corresponding improvement in decrease in diarrhoeal rates (Clemens and Stanton, 1987).

In Zimbabwe hands traditionally are rarely washed after defaecation. Part of this study explores when hands are traditionally washed and how this hygiene behaviour differs in the rural areas, where one would expect traditional behaviour to be most intact, from the commercial farms and the peri-urban area where the study took place. In Zimbabwe the different hands are used for different purposes. For example people eat with the right hand and use the left hand for anal cleansing after defaecation. Soap is almost never used for hand-washing. In one Zimbabwean study the hands of 40 rural children were tested for faecal contamination by pouring water over them. It was found that the hands were contaminated with an average faecal coliform count of 198.6/100ml of water (National Master Plan vol. 4.2, 1985). Therefore hands may act as a vehicle of spread in the transmission of diarrhoeal diseases. In past studies from western countries Escherichia coli (E.coli) was not found on the hands of 100 lab staff but was found on 12% of butchers hands. There was a 99% reduction after 1 hour in the number of E.coli on the hands (Pether and Gilbert, 1987).

2.2. Faecal Indicator Bacteria:

In this study hands were examined for faecal coliforms, which are Gram negative enteric bacteria and faecal streptococci (Group D streptococci), which are Gram positive enteric bacteria. These two bacteria are the most commonly used indicators of faecal contamination in water analysis. Both are excreted by all warm blooded animals, including humans. And with both the problem of non-faecal origin arises. For example a faecal coliform is defined as a coliform which ferments lactose with the production of acid and gas within 24-48 hours at 44°C

Faecal streptococci also present difficulties as there are also non-faecal strains of this group of streptococci, which cannot be differentiated by culturing from those of faecal origin. Yet there are no suitable alternatives to detect faecal contamination. Therefore both were used as it was hoped that this would partially overcome the shortcomings of both.

In a study done in the USA faecal coliforms outnumbered faecal streptococci by a ratio of 4:1 in human faeces. Animal faeces in contrast may have a ratio of 1:4 faecal streptococci to faecal coliform. However the ratios vary widely in different geographical locations and with different animals (Feachem, et al, 1983). The ratios will also change once excreted due to different die off rates.

On the skin Gram positive organisms are more common, with hands having fewer bacteria than the hair, face and axilla. The greatest number of bacteria on the hands are around and under the fingernails (Steere, et al, 1975). Because Gram negative bacteria are more sensitive to drying, Gram positive bacteria, and therefore faecal streptococci may survive for longer on the hands.

One advantage in measuring the number of faecal coliforms is that they do act as pathogens. Many other enteric pathogens are also Gram negative rods, although not faecal coliforms.

In order to determine the actual number of bacteria required to initiate an infection under laboratory conditions an infective dose is calculated. The infective doses of some common enteric pathogens are listed below:

E.coli 10^6-10^8
Salmonella sp. 10^4-10^8
Shigella sp. 10-200
Vibrio cholerae 10^8

However it must be remembered that these are calculated under experimental conditions using healthy, well-nourished adult volunteers. In an outbreak the infective dose may be much lower than those listed above. For example less than 100 E.coli have been known to initiate infection in children drinking contaminated well water in a study in Africa (Drasar and Barrow, 1985).

2.3. The Use of the Mukombe:

Obviously with research showing hand-washing to be a potential method for preventing diarrhoeal diseases, various methods have been explored to encourage hand-washing. One such idea is a simple hand-washing facility which was devised in Howard, Chiweshe, Zimbabwe a few years ago and which is fitted inside the latrine. The mukombe, a large, fleshy fruit is dried out and the insides removed to make a water bottle. The end is cut off and fitted with a cork which has a slit in it. When the mukombe is hung in the latrine and tipped with the hand a small quantity of water comes out of the slit, which is sufficient to wash the hands. A small bar of soap can also be hung form the mukombe. The mukombe is a cheap, hygienic and effective hand-washing facility using a natural, locally available material. It also makes economical use of water. However this idea has not been successful in the Chiweshe area due to several reasons. The mukombe fruits are often difficult to find because they only grow in certain areas of the country and they rot easily. People tend to associate them with drinking water or beer and are therefore hesitant to use them for other purposes. The use of tippy taps has also been explored in Chiweshe. These are plastic containers which hold approximately 4 litres and have a hollow handle. These are the containers in which cooking oil, beverages or fabric softener are purchased. In order to make a tippy tap, the base of the handle is heated and the plastic squeezed closed. Using a hot nail, a hole is made 2mm above the bend in the plastic. On the other side of the bottle, two holes are made at the same level and a piece of string put through to suspend the bottle. Due to plastic shortages over the last year the bottles were in very short supply.

In view of these problems we proposed a new design to hold 2 litres of water and made of galvanized metal as this is easily obtainable even in rural areas. The mukombe made from galvanized metal sells at ZW$8.00/each and was made by a tinsmith in Harare. Other materials considered included plastic (ZW$ 35.00/mukombe) and fibreglass (ZW$56.00/mukombe + $280 for the mould). These later two were rejected due to the obviously prohibitive high cost.

2.4. Study Areas

This study took place in three areas in Zimbabwe, on commercial farms, in a rural area and in a peri-urban area, near the capital. Both the commercial farms and the rural area are located in the province of Mashonaland East.

In Zimbabwe the rural or communal areas constitute 42% of the land mass and 60% of the population. The majority of people living in these areas engage in subsistence farming. The commercial farms constitute 43% of the land area and 20 % of the population. Mashonaland East is in a favourable natural region and is part of the hub of crop production for Zimbabwe. Commercial farms employ many immigrants from Malawi and Mozambique as well as Zimbabweans as labourers.

The peri-urban area, Epworth, has a population of approximately 40,000, and a high population growth rate. There are many immigrants living in Epworth as well as people from all over Zimbabwe. It was hoped that these three areas together would give a representative picture of Zimbabwe.

3 Methodology

The following is a description of the various methodologies implemented in this study:

3.1 Preliminary Studies

3.1.1 Microbiological Methods

In order to determine what microbiological methodology would be used for the main survey a three month preliminary study was undertaken to explore three different methods. These methods were:

1. a swab technique.
2. a glove technique.
3. a bowl technique.

With the swabbing technique cotton wool swabs were dipped into quarter strength Ringers solution. All areas of the hands were swabbed, a separate swab used for each hand and placed into Ringers solution. 50ul and 100ul quantities were plated onto MacConkey Agar, which is a highly selective media used for the recovery of Gram negative enteric bacteria, and incubated at 37°C for 24 hours. On this media E.coli has a characteristic morphology. Out of 40 plates only one colony morphologically characteristic of E.coli was isolated. The same technique was tried again but in addition a dry swab was wiped over the hands after the Ringers saturated one. The swabs were left for four hours and the bottles containing the swabs were vigourously vibrated for a few seconds before plating. It was hoped that these changes would increase the number of E.coli isolated , however no E.coli were isolated. Therefore the swabbing technique did not seem to be an effective way of isolating E.Coli. The swab was also not considered to be a reliable quantitative method because many bacteria could remain trapped in the swab. Calcium alginate swabs which dissolve completely in Calgon Ringers solution and therefore give a more reliable quantitative count were not available in Zimbabwe.

Gloves are also not easily available nor easy to sterilize without causing them to deteriorate rapidly. The glove technique which comprises removing E.coli from gloves placed on the hands, was rejected because of the unavailability of appropriately made gloves in Zimbabwe.

The bowl technique was chosen because it was thought to give more accurate bacteriological counts than the swab technique. The bowl technique simply comprises washing hands in a bowl of water, and the water being collected for analysis. It was also thought to be an accurate representation of the Zimbabwean traditional hand-washing process, which involves passing a bowl of water from person to person. By using two hand-washings per person it was hoped that a more accurate figure for faecal indicator bacteria removal could be obtained. It was hoped that the first hand-washing would indicate the number of bacteria removed from the hands and the second hand-washing would be an indicator of the number of bacteria left on the hands. (See Section 5 for a discussion on the data interpretation)

3.2 Methodology for Traditional Handwashing Phase

3.2.1 Microbiological Methodology

The hand-washings were filtered as for a water sample. The techniques used are as described in the United Kingdom Bulletin HMSO no. 71 (DHSS 1982). In brief, the hand-washings were filtered in volumes of 10ml, 25ml, 50ml or 100ml depending on the turbidity of the water. The aim was to filter the largest amount of water possible so as to provide the most accurate estimate of the number of faecal coliforms or faecal streptococci. The sample was filtered through a membrane filter which traps the bacteria, the pores in the membrane measuring 0.45 um in diameter. This membrane was then placed on a saturated pad of membrane lauryl sulphate broth and incubated at 44°C for 12-18 hours for the isolation of faecal coliforms. All yellow colonies were counted and reported per 100ml of water. A few modifications were made to this standard method in order to increase the number of faecal coliforms isolated. Because the media tended to dry out, plastic bags were placed around the plates to prevent evaporation. In addition to this 2.5ml of media was accurately measured out to give a slight excess of media. Finally a minimum of 2 hours at room temperature before incubation at 44°C was introduced in the hope that this would aide the resuscitation of stressed microorganisms. For the isolation of faecal streptococci the membrane filter was placed on a plate of Slanetz and Bartley Agar (Membrane Enterococcus Agar) and incubated for approximately 4 hours at 37°C and then 48 hours at 44°C. All pink, red and maroon colonies were counted and expressed per 100ml of water. Both the membrane lauryl sulphate broth and the Slanetz and Bartley Agar are manufactured by Oxoid Limited, United Kingdom, see Appendix 5 for formulae.

3.2.2 Sociological Methodology

Again a preliminary study took place which consisted of observation to determine what factors concerning hygiene might be important to include in the questionnaire asked of the mothers. Also information concerning food preparation, hand-washing and mothers daily activities was gathered to discover key areas where further observation of the families was thought to be necessary.

The questionnaire was developed with assistance of the Sociology department of the University of Zimbabwe and Mr. P. Cross, Water and Sanitation Advisor, Ministry of Health. The questionnaire was pretested on ten families and alterations made where necessary. The final questionnaire is presented in annex 1 together with the training notes.

3.2.3 Choice of Study Areas and Families

Mashonaland East province was chosen due to its proximity to Harare, and the enthusiastic cooperation received from the Mashonaland East Provincial Medical Officer to conduct the study in this area. Many Ventilated Improved Pit Latrines (Blair Toilets) had already been constructed in this province indicating a high level of health awareness, so that the response to the hand-washing study was hoped to be positive.

The study was conducted in three areas, a Peri-urban area, a rural area (Communal Land) and a Commercial farming area. It was decided to use 12 years of age as a cut off point fo rthe children to be involved in the study because these are the children considered most at risk from diarrhoea.

Epworth was chosen as the peri-urban area because of its close proximity to Harare.

There were no lists of households available from provincial sources for the villages in the rural areas, so the ZANU(PF) chairman for the area was approached and asked for a list of households in Nehanda Central VIDCO, part of Chiota West. This area was selected by the Mashonaland East Provincial Health Inspector because of its proximity to Harare, the good quality of the roads throughout the year and the known cooperation of the people living in this area. After several weeks of waiting a list of households for only one village was received. The project could not be held up so this village was used by default.

A list of commercial farms in Mashonaland East province was obtained from the Provincial Medical Officers office. Three farms were chosen where cooperation from the farmers was good, and which were easily accessible from Harare. From lists of families obtained from the farmers twenty seven families were randomly chosen to be included in the study. All of these families had children of 12 years old or under.

In order to select the households in Epworth for inclusion in the study the Ministry of Local Government was approached and asked to provide a list of plot numbers in two areas of Epworth, Epworth 2B a "squatter area", and Epworth 5B, a "settler area" were selected. Plot numbers are not necessarily synonymous with individual households, with a plot often comprising a family that owns the property, together with lodgers. For the purpose of this study the plot owner householders were concentrated on as they tended to be a more stable population than that of the lodgers. Lodgers were more reluctant to answer the questionnaire because they feared reprisals from their landlords if they answered the questions in a critical fashion.

In summary eighty families from the three areas were selected as follows :
27 families from Nyamungaya Village, Chiota Area.
27 families from three commercial farms.
26 families from 2B and 5B areas of Epworth.

If the families were not at home when the sampling team arrived, the properties were visited an additional two times. If on the third time the family was still not there, for example the mother might have been working full time, another family was chosen from the household lists.

If a family member was not present a note was made of their name and where they might be found. For example all children attending school were listed and later visited at the school in order to have their hands tested.

It cannot be denied that the choice of sampling areas was far from random, but strong constraints on the project made this inevitable. Firstly all sites chosen had to be close to Harare so that samples could be quickly analyzed at the Blair Research Laboratory. Secondly the wishes of some key personnel, whose cooperation needed to be obtained, had to be taken into account, and thirdly this study was to have some concrete practical implementation. That was that mukombes were to be installed . It was necessary to chose areas where their installation would be favourably received.

3.3 Soap Study: Choice of Families

39 families were randomly chosen from the 80 who took part in the traditional hand-washing section of the main study. Only mothers and those children at home were tested.

3.4 Mukombe Study: Choice of Families

50 families were chosen to receive mukombes. These families were not chosen randomly because it was thought to be important to include influential members of the communities, such as Village Health Workers, because it was thought this would make the mukombe more acceptable to the communities. Each family was supplied with a nail and some string on which to hang the mukombe. The mukombe was filled with water to check for leaks and a demonstration on its use was carried out. A brief discussion was held with all family members present to explain the mukombes use and an instruction sheet given to each family, suggesting times for hand-washing using the mukombe.

3.5 Method for Each Household

3.5.1 Traditional Handwashing: Method for each household

On each day 3 to 5 families were visited. A brief introduction and explanation about the project was given to each mother taking part in the study. The questionnaire was administered to each mother and lasted from 20-60 minutes. Each mother, female relative involved in child care and any children living in the household between the ages of 1-12 were asked to wash their hands. With children under the age of 2 there was often reluctance to cooperate. Each person was given a sterile aluminum bowl filled with 450 ml of sterile distilled water and asked to wash their hands in their usual manner. This was repeated with another bowl filled with 450 ml sterile distilled water. These samples were transported back to the laboratory and analyzed within six hours as described above.

3.5.2 Hand-washing with soap: Method for each household

In the 39 households randomly chosen, all children, female relatives involved in child care and mothers were asked to wash their hands. Again 450 ml of sterile distilled water in a sterile aluminum bowl was used. Each person was given a small piece (3cm) of Perfection soap (manufactured by Olivine Industries). Using the piece of soap the person washed their hands. Then the person was asked to wash their hands in a second bowl of sterile distilled water without using soap. Again the samples were transported back to the laboratory and analyzed as described above.

3.5.3 Mukombe Study: Method for each household

Each of the 50 families that received a mukombe was visited and observations were carried out to determine whether or not the mukombe was being used. Each mother was asked a short questionnaire about the use of the mukombe. This questionnaire is attached as part of annex A1.

A 200ml sample of the water in the mukombe was taken. The mother was then asked to wash her hands using the mukombe, the water coming off her hands being collected in an empty sterile aluminum bowl. The mother then washed her hands in the usual fashion in 450 ml of sterile distilled water in a sterile aluminum bowl. These three samples per mother were then analysed within three hours as described above. For each mother with a mukombe another mother nearby was chosen to act as a control. This woman was asked to wash her hands in two bowls filled with 450ml of sterile distilled water as described previously.

4. Introduction to Results Section

As stated in previous sections of this report, the study was divided into three sections in order to look at:

1. The effectiveness of traditional hand-washing
2. The use of soap in hand-washing
3. The effectiveness and cultural acceptability of the Mukombe.

Below is the list of annexes containing the questionnaires, materials used, analysis and results of the study:

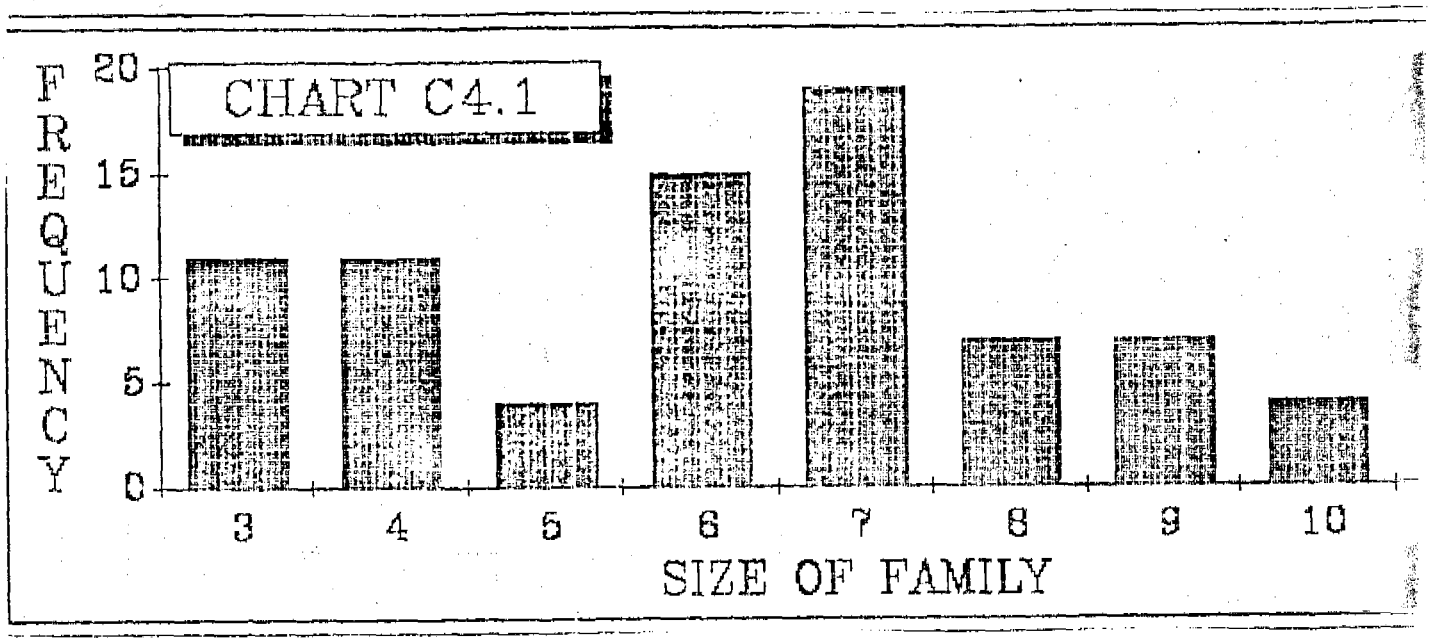
Annex A1: Traditional hand-washing and Mukombe questionnaires with notes on their administration.
Annex A2: Results of traditional hand-washing questionnaire
Annex A3: The individual and family microbiological indices
Annex A4: Results of the Mukombe questionnaire
Annex A5: Media formulae

An analysis of the results obtained can be found in the following four chapters:

4. Comments on Family Characteristics
5. Data Interpretation
6. Identification of Variables Influencing Bacterial Counts
7. Factors That Were Expected to be Correlated with the FMI, But in Fact Were Not.

only visit the home in Epworth or the farm occasionally.

Chart C4.1 Family Size Distribution.



4.4 Average Number of Children Adults and Family size by Area

Table 4.3 Mean Number of Children, Mean Number of Adults and Mean Family Size Split by Area.

Area	Mean No Children	Mean No Adults	Mean Family Size
Peri-urban	3.0	3.4	6.4
Farm	2.6	2.8	5.4
Rural	3.0	3.9	6.9

The table indicates that the average family in the sample comprised 3 adults and 3 children, with the farms having the least average family size and the rural area having the highest average family size. This agrees with the expected pattern.

4.5 The Age Distribution of the Children Sampled

The children sampled were 12 years old and under, with the average being 6 years of age. Chart C4.2 shows the number of children sampled in each age group. There are comparatively few under 2s in the sample because children o this age are not really able to wash their hands on their own, and even if they are they were seldom willing to cooperate with researchers! After the age of 5 children start going to school, so that the children were not so readily available to be sampled, hence the decline in numbers after the age of 5. Since the cut off point for the definition of a child was 12 years old children stated to be of this age are likely to be over represented in the sample as a result of the eagerness of mothers to have their children included in the study.

4 Comments on Family Characteristics

4.1 The Sample Split by Area

80 families were sampled in the survey, 27 of these were from a village in Chiota West Ward, the rural area, 26 were from Epworth the peri-urban area and 27 from three commercial farms near Marondera.

Table 4.1 shows the number of children split by sex sampled in each of the three areas, the number of adults and the total number sampled altogether.

Table 4.1 Number of People Sampled in Each Area.

	Children			ADULTS	TOTAL
AREA	Male	Female	Total		
Rural	35	35	70	32	102
Farm	30	26	56	27	83
peri-urban	25	32	57	32	89
TOTAL	90	93	183	91	274

As the table shows, an almost equal number of adults and children were sampled in each area, and the children were equally divided between the two sexes. It was the intention of the survey to collect data evenly between the three areas in order to make the results comparable.

4.2 Who Answered the Questionnaire

The questionnaire was given to the mother of the family group, and if the mother was not there then it was given to either the grandmother or another female relative. The number of people in each of these categories is given in table 4.2.

Table 4.2 Who Answered the questionnaire.

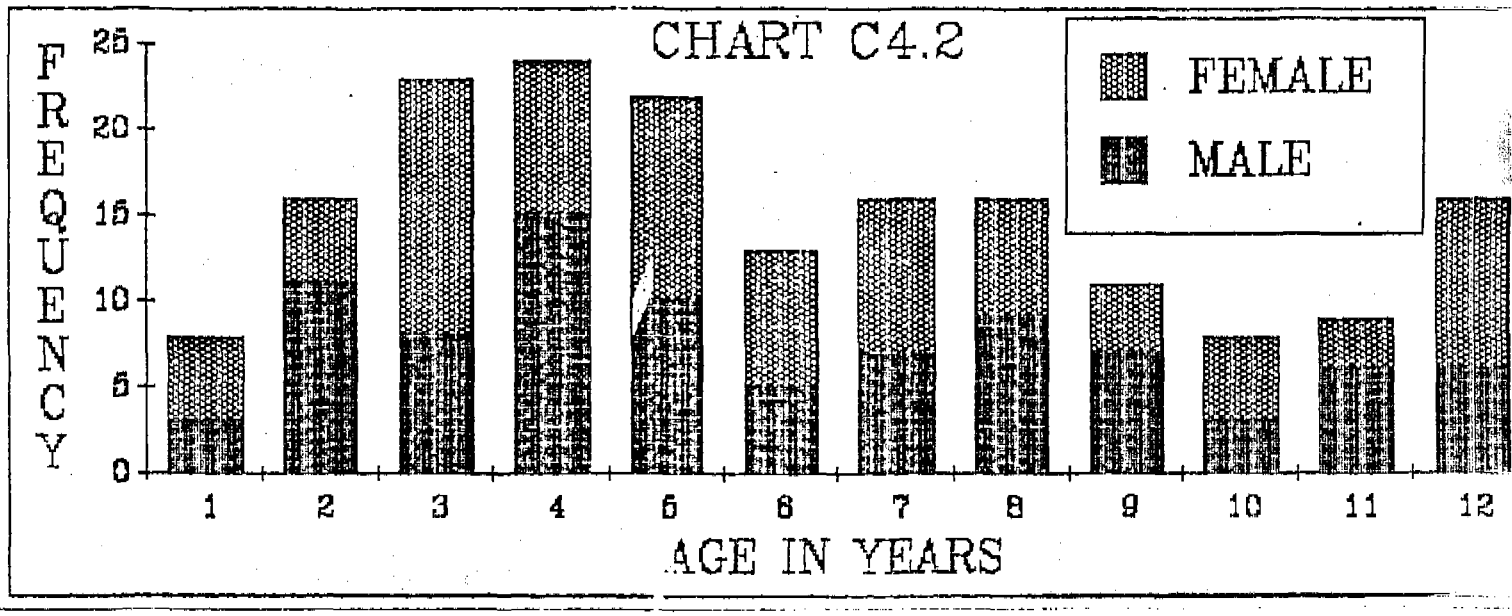
	Mother	Grand Mother	Female Relative	Total
Frequency	70	8	2	80

The table shows that the most common respondent to the questionnaire was the mother which comprised 87.5 % of all responses, grandmothers and other female relatives made up the other 12.5 % of the sample.

4.3 The Distribution of Family Size

The average family size was 6.3 persons/household, which compares to the official 1982 Census estimate of 4.7 persons/household. Family size varies throughout Zimbabwe from region to region, and is difficult to collect because of the frequent absence of family members, particularly of male workers. In addition in the families sampled in Epworth and the commercial farms, family members would often stay at a home in the rural areas, and

Chart C4.2: Age Distribution of Children Split by Sex.



4.6 Demographic Comments

In conclusion the sample is a fair representation from Zimbabwe as a whole, and no significant biases seem to have been incorporated into the sample population.

5 Data Interpretation

5.1. The 3 Sections of the Study

The study can be split into three parts from a microbiological viewpoint. These parts are associated with the three different hand-washing methods investigated, which are:

1, Traditional hand-washing.
2, Hand-washing using soap.
3, Hand-washing using the mukombe.

Each method has four microbiological variables recorded for each person. They are:

1, Faecal coliform count from the first wash.
2, Faecal coliform count from the second wash.
3, Faecal streptococci count from the first wash.
4, Faecal streptococci count from the second wash.

5.2. The Case Control Study for the Mukombe.

Section 3 of the study was carried out as a case control method. 97 people were sampled, approximately half of which used mukombes and half used a control method. The control method was traditional hand-washing, that is a method identical to that used in the first section of the study.

One fortuitous advantage of using the traditional method as a control was that it could be contrasted with the original traditional hand-washing data. This meant that an idea of how consistent the data was could be achieved. The results were very encouraging, leading to the conclusion that the data collected was a reliable and consistent method of measuring faecal contamination.

In order to overcome an intrinsic limitation of the mukombe hand-washing data, bacteriological samples of the water in the mukombe were taken. The problem associated with analysing the mukombe hand-washing data, was that it was the only part of the study in which contaminated water was used to wash the hands. In all other parts of the project distilled water was used, so that in the case of the mukombe data, high bacteria counts from hand-washing could be partially attributable to contaminated water in the mukombe.

It was not possible to simply subtract the degree of contamination of the water in the mukombe from the raw hand-washing counts because this would have frequently led to a nonsensical negative figure. The simplest alternative method to straightforward subtraction was "division". The average bacteria count for the water in the mukombe was calculated along with the average bacteria count for hand-washing. The average percentage of hand-washing contamination that could be attributable to contamination of water in the mukombe was then calculated, and all raw data counts for the mukombe study were then divided by the appropriate coefficient. Table 5.1 shows the derivation of these coefficients for faecal coliforms and faecal streptococci for the mukombe hand-washing data.

Table 5.1 Derivation of Adjustment Coefficient for Mukombe Data.

Faecal Bacteria	Average contamination of water in mukombe.	Average contamination of water from hands.	Percentage of contamination attributable to mukombe.	Coefficient for division.
Coliform	45	170	26%	1.36
Streptococci	264	745	35%	1.55

Mukombe hand-washing data presented in the report will be corrected for contamination of water in the mukombe.

5.3 Notation for Study Sections

A 'T'is used to stand for traditional hand-washing ,'S'for soap hand-washing and 'M' for hand-washing using the mukombe, 'C' for Faecal coliforms and 'S' for Faecal streptococci, and '1' for the first washing and '2' for the second washing. In addition a subscript of "a" is used to denote the case part of the mukombe study and a subscript of "b" to denote the control part of the study. The following notation will be used to identify to study sections.

Table 5.2: Notation for Study Sections.

	FAECAL BACTERIA			
	COLIFORM		STREPTOCOCCI	
METHOD	Wash 1	Wash 2	Wash 1	Wash 2
Traditional	TC1	TC2	TS1	TS2
Soap	SC1	SC2	SS1	SS2
Mukombe Case	$MC1_a$	$MC2_a$	$MS1_a$	$MS2_a$
Mukombe Control	$MC1_b$	$MC2_b$	$MS1_b$	$MS2_b$

There are three hand-washing methods, two bacteria types and two parts to the hand-washing process (first wash and second wash).

5.4. Data Interpretation

5.4.1. Interpretation of TC1, TS1, SC1, SS1, $MC1_a$, $MS1_a$, $MC1_b$, $MS1_b$

The microbiological counts will be determined by four main factors. These are:

1. The number of bacteria present on the hands.
2. The effectiveness of the hand-washing method used.
3. The thoroughness of the hand-washing.
4. Experimental error.

Possible confounding as a result of the different degrees of the thoroughness of hand-washing is hopefully negated as a result of the large random sample. The problems assosciated with experimental error (notably in counting colonies on the plates) will be partially overcome by a logarithmic data transformation when appropriate.

This still leaves the data subject to variation from the first two factors, that is, the number of bacteria present on the hands and the effectiveness of the hand-washing method used. As only one result is recorded it is impossible to determine the degree that each factor effects the results.

However, if it is assumed that the distribution of the number of bacteria on peoples hands was identical for both the traditional, soap and mukombe studies, then the variation in the results can be accounted for by the effectiveness of the hand-washing method alone.

The mean of the log transformed data for the washing process will be taken as an indication of the effectiveness of any one method, with the ordering being, the higher the mean the more effective the method.

5.4.2. The interpretation of TC2, TS2, SC2, SS2, $MC2_b$, $MS2_b$.

The second wash data will not be used as originally anticipated as an indication of the number of bacteria left on the hands after washing, but will be used in conjunction with the first wash data to establish an index of ease of removal of any one type of bacteria. This can be interpreted as the "stickiness" of the bacteria.

The hypothesis that the second wash count is an indication of the number of bacteria left on hands after the first wash was rejected because the mean of SC2 was higher than the mean of TC2 and the mean of SS2 was higher than that of TS2. That is even though the soap method was removing more bacteria than the traditional method during the first wash, and therefore there were fewer bacteria left on the hands after the soap method, there was no associated decrease in counts after the second wash when using the soap method. Table 5.3 Shows the mean counts for the 12 comparable result categories.

Table 5.3 Mean bacteria counts.

	FAECAL BACTERIA			
	COLIFORM		STREPTOCOCCI	
METHOD	Wash 1	Wash 2	Wash 1	Wash 2
Traditional mean	TC1 56	TC2 21	TS1 298	TS2 119
Soap mean	SC1 164	SC2 36	SS1 564	SS2 175
Mukombe Case mean	$MC1_a$ 125	$MC2_a$ *	$MS1_a$ 480	$MS2_a$ *
Mukombe Control mean	$MC1_b$ 58	$MC2_b$ *	$MS1_b$ 349	$MS2_b$ *

* Case and control 2nd wash not comparable due to contaminated water in the mukombe.

5.5 The Stickiness of Bacteria

The justification for interpreting the second wash count in conjunction with the first count as an index of ease of removal of a type of bacteria is as follows.

Six linear regression analyses were carried out on the following sets of data pairs: (TC1,TC2) (SC1,SC2) ($MC1_b$,$MC2_b$) (TS1,TS2) (SS1,SS2) ($MS1_b$, $MS2_b$). The reason for leaving out $MC1_a$, $MC2_a$ and $MS1_a$, $MS2_a$ was that because of contamination of the water in the mukombe the method was not strictly comparable. The logarithm of both the independent and dependent variable was taken in all cases. The second variable in each of the pairs was counted as the dependent variable, and the regression line was forced through the origin to fit with theoretical considerations. Table 5.4 table shows the coefficients that were calculated from the analyses.

Table 5.4: Constrained regression analysis of microbiological data.

Pair	TC1 TC2	SC1 SC2	$MC1_b$ $MC2_b$	TS1 TS2	SS1 SS2	$MS1_b$ $MS2_b$
B	0.535	0.556	0.602	0.700	0.708	0.706
95% CI for B	[0.579 0.592)	[0.478 0.635)	[0.468 0.736)	[0.666 0.735)	[0.645 0.771)	[0.594 0.817)
Adjusted R^2	0.572	0.731	0.647	0.858	0.871	0.779
N.	259	73	44	265	74	46

The interpretation of the statistic "B" is that it is the slope of the regression line, the 95% CI for B is simply a 95% Confidence Interval for B. N refers to the number of observations used to form the model. The small sample size for the mukombe study means that the confidence intervals are necessarily large. The "adjusted R^2" is a measure of how well the data fits the model. In this case the high values of R^2 give a misleading picture of how well the data fits the model because;
1/ the model is constrained through the origin and
2/ the signal to noise ratio of the data is low, so that R^2 overestimates the fit of the model.
The B coefficients are all very similar for the faecal coliform data and similarly all approximately the same for the faecal streptococci data. The interpretation is that the B coefficients are only related to the type of bacteria and not the method of hand-washing. The B coefficient for faecal coliforms is about 0.55 and 0.7 for faecal streptococci. This means that a smaller percentage of faecal coliforms than faecal streptococci are washed off the hands during the second wash, leading to the conclusion that faecal coliforms are "stickier" than faecal streptococci.

6 Identification of Variables Influencing Bacteria Counts

6.1 Introduction

6.1.1 Data Selection

For the purposes of this investigation only the data from the traditional hand-washing method is used. The reason for this is that it is drawn from the largest sample population, that is 274 individuals, and was carried out over the longest period of time, October 1987 to January 1988, so that temporal variations will be better represented. Also only data from the first wash part of the traditional process (TC1 and TS1) is used because this is the best indicator of the amount of contamination of faecal bacteria on the hands.

6.1.2 The Individual Microbiological Index And the Family Microbiological Index

The purpose of defining the IMI and the FMI was to produce a measure that combined information from both the faecal coliform and faecal streptococci counts in a meaningful way, and also possessed convenient statistical properties (see Annex A3 for an explanation and derivation of the IMI and FMI).
An Individual Microbiological Index (IMI) was calculated for each person, which combined, after various transformations, data from both the faecal coliform and faecal streptococci counts. The FMI was derived by averaging the values of the IMI within a family. The index was ordered and so useful for determining which factors were the most influential in affecting the level of faecal contamination on hands.

6.1.3 Categorization of Variables

Variables affecting the FMI can be divided into four heiracal categories for the purposes of the analysis, however boundaries between the four categories are of course not that well defined. These categories are explained in Table 6.1

Table 6.1 Hierarchical Categorization of Factors Influencing Faecal Contamination.

Category	Name	Description	Example
1	Environmental	Geographic & natural variations.	Climate.
2	Human Intervention	Man's impact on the local environment.	Land use.
3	Particular	Socioeconomic status of the family.	Income or family size.
4	Behavioural	Specific practices carried out by the family.	Personal hygiene.

6.2 Analyses of the Influential Variables

6.2.1 Environmental Factors

Environmental factors that might have been able to account for some of the variation in the data include the actual geographic location of the individual and climatic factors. The environmental factors are interrelated, for example geographic location and climate are obviously highly dependent, so that a consideration of only one environmental factor will give information on the others. It was considered that meteorological information was likely to be of importance. In addition it was readily available and reliable.

Information was collected on three climatic variables: temperature, humidity and rainfall. Of these humidity was chosen for intensive investigation in preference to the others because temperature showed very little variation over the period that the traditional hand-washing data was collected, and the intermittent nature of rainfall meant that many of the days when sampling was carried out were rainfall free. It is possible that just the process of raining on its own might make a difference to the results, but because humidity is correlated with rainfall, it was considered that rainfall effects could be subsumed into humidity effects. Relative humidity had a wide range over the study period, (40% relative humidity to 90% relative humidity), so that it was possible to carry out statistical tests that would show correlations if they existed.

The raw data was collected from two stations, Katsuga near Epworth, and the other at Marondera that is equidistant from the commercial farms and Chiota. These two stations are the nearest to the areas of investigation and represent the best possible available information. However it would have been desirable to have information recorded at the investigation sites themselves.

As mentioned in the introduction, the large variation in the bacteria counts means that it is unlikely that any one variable itself will explain much of this variation. However what can be hoped for is that significant positive or negative correlations exist between the variables in question. Since faecal coliform and faecal streptococci are different species of bacteria it is possible that humidity will affect them in a different manner, so that analyses was carried out for both species.

In order to determine the basic nature of the relationship between humidity and bacteria counts, the days that data was collected on were split into two distinct categories. Days were considered either high humidity days or low humidity days, with the cut off point being derived in order to split the data into two equal sized groups. The distribution for faecal coliform and faecal streptococci counts under the two humidity levels is shown in pie charts P6.1 and P6.2. The common relationship shown by both both faecal coliform and faecal streptococci1 counts is that under high humidity conditions the percentage of high counts increases, indicating that higher humidity leads to higher bacteria counts. The increase is more pronounced for faecal streptococci than for faecal coliforms.

The 3 count ranges for the comparison of the humidity counts.

Low = 0 - 6 /100ml.
Medium = 7 - 126 /100ml.
High = 127 - 1000 /100ml.

The count ranges were decided on by using a logarithmic based scale, with the low count containing 3 of the log units, the medium count containing 4 of the units and the high count again containing 3 units.

Chart P6.1: A Comparison of Faecal Coliform Counts Under Low and High Humidity conditions, Split into Three Count Ranges.

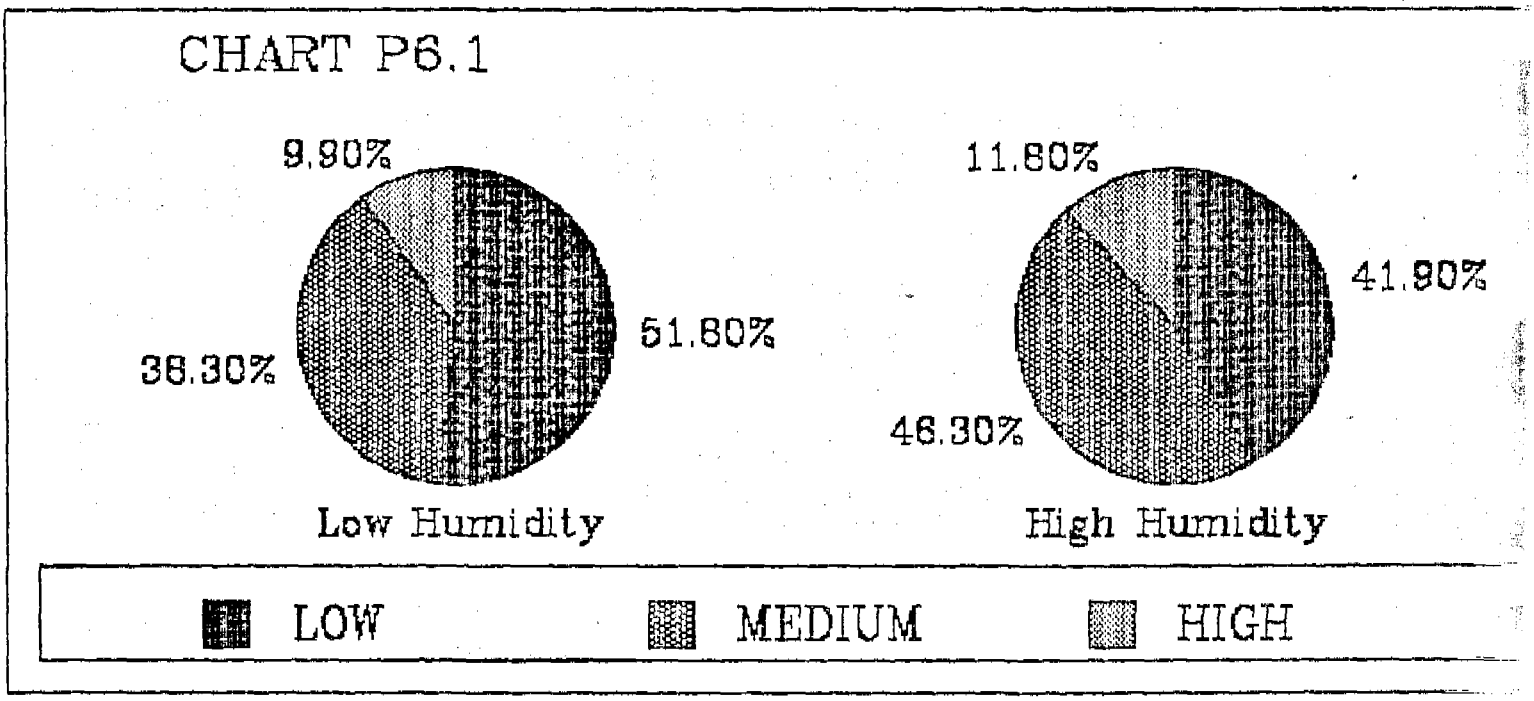
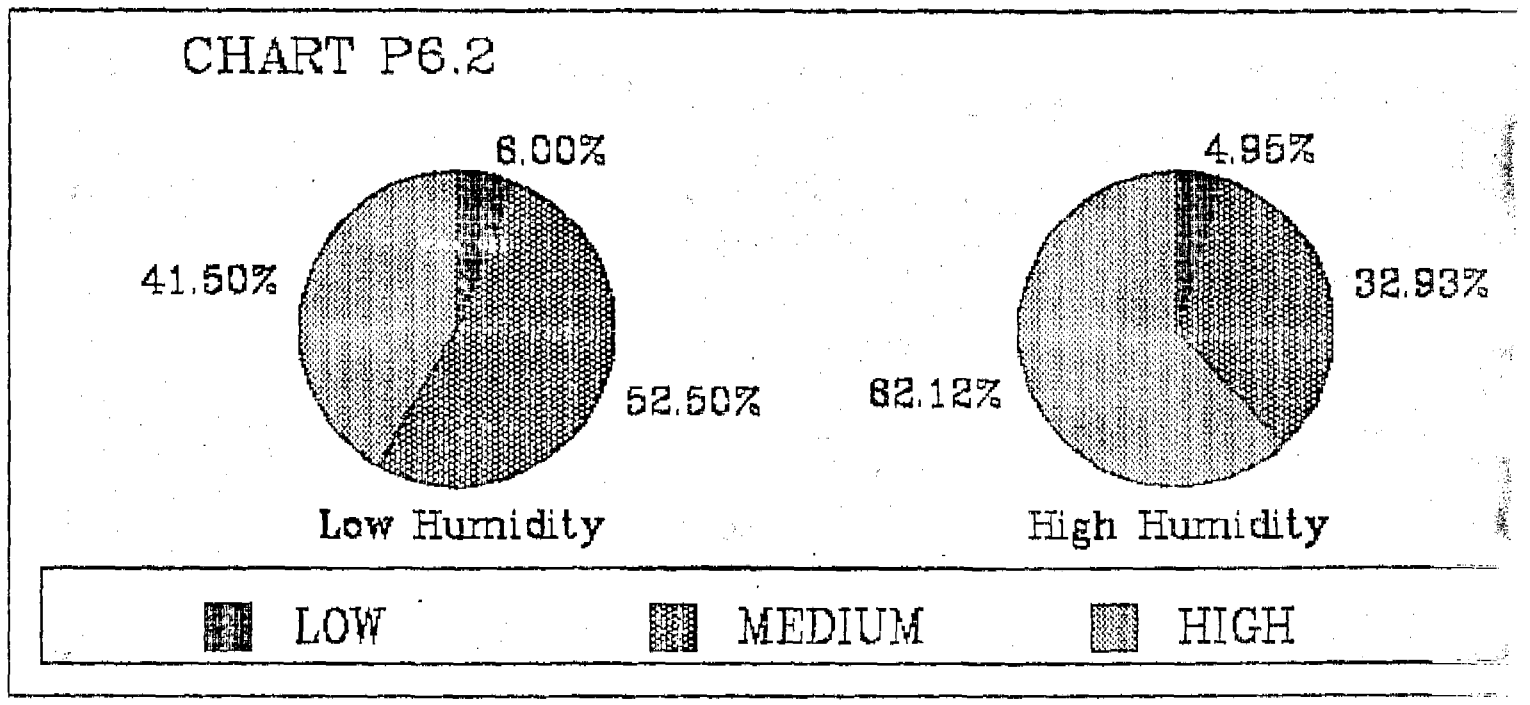


Chart P.2: A Comparison of Faecal Streptococci Counts Under Low and High Humidity.



Counts in chart P6.1 fall from 51.8% under low humidity to 41.9% under high humidity conditions, with the change being compensated for in the medium level counts. For faecal streptococci the same basic picture emerges but it is more pronounced and occurs between the medium and high counts rather than the low and medium.

Table 6.2 shows how the mean counts change under the two humidity conditions for faecal coliforms and faecal streptococci.

Table 6.2: Means of Faecal Coliform and Faecal Streptococci Counts Under Low and High Humidity Conditions per 100 ml water.

Faecal Bacteria	Humidity Mean Counts	
	Low	High
Coliform	41	53
Streptococci	235	348

The mean is greater for high humidity in both cases. Considering the nature of the raw data itself a non-parametric test was carried out to see if there was a difference in medians, for faecal coliforms and faecal streptococci, under the low and high humidity conditions. The levels of significance from this test for faecal coliforms and faecal streptococci respectively were 0.189 and 0.002. The conclusion drawn is that a rise in humidity increases both faecal coliform and faecal streptococci counts, but has a more pronounced effect on faecal streptococci where the influence of humidity is highly significant. A rule of thumb derived from a regression analyses of humidity and bacteria counts indicates that a rise in relative humidity of 5% will on average increase faecal coliform counts by 2 and faecal streptococci counts by 23.

In summary humidity is positively correlated with both faecal coliform and faecal streptococci counts but only significantly so for faecal streptococci. Humidity does not explain all of the variation of the bacteria counts, but it is a useful finding to have made and bears out in the field, work that has been done under laboratory conditions and in hospitals. (See Stuttard, 1961 and Lowbury, 1969.)

Research indicates that humidity will have an increasing effect on faecal contamination as one progresses from the southwest of the country to the northeast. More importantly is the yearly cycle of humidity. On average for four months of the year starting in December relative humidity exceeds 70%, the level at which a significant rise in faecal contamination due to humidity has been observed to occur.

6.2.2 Human Intervention Factors

The human intervention factor that was found to significantly influence the FMI, was the type of area that the family lived in.

For this analyses only the FMI will be used because of its convenient statistical properties, but the results remain valid if faecal coliform and faecal streptococci counts are looked at separately, and the raw averages are included for them as a matter of interest.

Land Classification

As previously stated areas were split into three categories: peri-urban, rural and commercial farms. It was found that commercial farms had the highest FMI followed by the peri-urban area with the rural areas displaying the lowest values. A summary of the results is given in Table 6.3

Table 6.3 Mean Counts for the FMI, and Faecal Coliform and Faecal Streptococci, Split by Area.

AREA	Mean FMI	Mean Faecal Coliforms	Mean Faecal Streptococci
Commercial Farm	0.368	62	364
Peri-urban	0.077	66	312
Rural	-0.420	41	228
Grand Mean	0.000	56	298

In order to determine the significance of the difference in the means a One-way Analyses of Variance was carried out on the FMI. This test simply computes the probability that the given results would have occurred if the means for three areas were all the same, in other words if the area that a family lived in made no difference to the value of the FMI. The test gives a significance value of 0.01 indicating that there is strong evidence to suggest that the means are in fact different, and that the area that a family lives in will influence the amount of bacteria present on the family members hands'. The reasons why this is so are numerous and considerable attention will be given to them in the next section.

6.2.3 Socioeconomic Factors

6.2.3.1 Infant in the Family

The first socioeconomic factor that was found to significantly influence the FMI was whether or not there was an infant in the family. An infant for the purposes of this study is defined as a child of two years of age or under. Table 6.4 shows how many infants there were in each of the three areas. It is necessary to consider this in order to make sure that having infants in the family is independent of area, so that one can reliably say that both 'area' and 'having an infant in the family' affect the FMI.

Table 6.4: Cross-tabulation of the Number of Families in Each Area With or Without an Infant

AREA	Infant	No Infant	Total
Commercial Farm	12	14	26
Peri-urban	14	12	26
Rural	10	17	27
TOTAL	43	36	80

A X› test was carried out to determine if area and having an infant in the family were independent. The significance level of 0.45 indicated that there was no evidence for dependence.

Table 6.5: Mean FMI Counts For Families With and Without an Infant.

	Mean FMI
Family With An Infant	0.237
Family Without An Infant	-0.226
Grand Mean	-0.016

The table shows that families with an infant had an average higher FMI than those without, indicating that all members of a family are prone to greater faecal contamination when there is an infant in the family, and not just the mother and infant themselves. Table 6.6 shows the mean values of the FMI for the three areas split by the occurrence of an infant in the family.

Table 6.6: Mean value of FMI by Area by Infant.

Area	Peri-urban	Farm	Rural	Grand Mean
Families with an infant.	**0.63**	**0.69**	**-0.78**	**0.24**
Families without an infant.	-0.35	-0.11	-0.21	-0.23
Grand mean	0.08	0.33	-0.42	-0.02

Even though having an infant in the family meant that on average significantly higher values of the FMI were recorded, this was not the case in all areas. In the rural areas an infant in the family actually decreased the value of the FMI whereas in the farms and peri-urban areas it increased it. A 2 Way ANOVA was carried out to investigate this, and a 2-way interaction significance level of 0.006 indicated that the FMI depended on the particular combination of which area the family lived in and whether or not there was an infant in the family. Reasons why having an infant when living in a rural area improves hygiene, but has the opposite effect in a farm or peri-urban area will be discussed later.

6.2.3.2 Differences Between Mothers and Children.

Three categories were defined, the first of which contained only mothers, the second contained children between the ages of 6 and 12, and the third contained children up to the age of 5. The mean value of the IMI was calculated for each of the three categories and the results are presented in table 6.7. along with the mean raw counts for faecal coliforms and faecal streptococci.

Table 6.7 Mean Values for the IMI and Bacteria Counts Split by Age Category

Category	Mean IMI	Mean Faecal Coliform	Mean Faecal Streptococci
Mother	0.25	68	332
6 to 12 Years	-0.34	33	237
0 to 5 Years	0.10	66	323

The test for a difference in means is significant for the IMI at the 5% level, leading one to conclude that it is mothers and young children who are most susceptible to faecal contamination.

6.2.4 Behavioral Factors

Not surprisingly the activity that the subject was engaged in just before he or she was sampled greatly influenced the faecal coliform and faecal streptococci counts. Because each member of the family might have been participating in a different activity just before sampling occurred, the IMI was considered the appropriate statistic to use.

Peoples activities were split into 7 different groups and an average value of faecal contamination is computed for each group. The standard deviation is also presented along with the mean value in each group, as some groups have very small numbers in them so that the mean value for that particular group will not be reliable. Table 6.8 presents this data.

Table 6.8: The Mean Value of the IMI for Various Activities, in Decreasing Order of Magnitude.

Activity	Mean IMI	σ IMI	Cases
Outdoor Physical	1.08	1.57	17
Coming Home	0.51	1.55	14
Indoor Physical	0.39	1.28	36
Playing	0.07	1.84	93
Sleep/Rest	-0.44	1.40	28
Water Activity	-0.48	1.46	15
School	-0.56	1.39	52
TOTAL	-0.01	1.63	255

Since some of the activity categories have so few cases in them it would be unwise to make sweeping generalization from these results. The nebulous heading of coming home took into account people who were vague in their response. In order to judge the reliability of this data it is necessary to see if the results are intuitively plausible. This is best achieved by looking at activity headings that contain a reasonable number of observations, and also have the property that faecal contamination as a result of the activity is easily predictable. Since faecal bacteria have a limited life span it would make sense for an activity that restricts the contact with the bacteria for a significant length of time to be associated with a low mean for the IMI. "Sleeping/Resting" is one such activity and has a mean IMI of -0.44, which is consistent with the hypothesis.

Some of the activity headings were very vague like "coming home" for instance, where the person did not make it clear exactly what he or she was doing. Significant differences exist between the group means, $p=0.002$, which indicates that some activities are more liable to lead to faecal contamination than others.

The reasons for this are that some activities bring the individual into contact with more bacteria, through contact with the soil etc. and others provide a less hostile environment to the bacteria as a result of sweating.

7 Factors That Were Expected To Be Correlated With The FMI, But In Fact Were Not

7.1 Prompted and Unprompted Questions

During the course of the socioeconomic questionnaire, prompted and unprompted questions were asked about which specific activities mothers associated with hand-washing. It was recognized that the prompted answers, which were asked at the end of the questionnaire, would not be reliable since people had by this stage of the questionnaire understood that it was concerned with hygiene, and were more likely to answer what they thought the interviewer wanted to hear, rather than the truth. This is born out by comparing the unprompted and prompted responses as shown in table 7.1. The purpose of asking the prompted questions was to compare how the responses would differ if a hand-washing time was suggested rather than the mother suggesting it. The unprompted questions should have given a more accurate picture of the true situation, but knowledge of the times that one should wash ones hands is no guarantee of action. The unprompted question is more likely to have shown how many people knew when they should have washed their hands rather than how many people did wash their hands.

Table 7.1: Comparison of Prompted and Unprompted Responses to the Question "When do you wash your hands?", Percentages

When do you wash your hands?	Prompted		Unprompted	
	No	Yes	No	Yes
Before meals.	0 %	100 %	26 %	74 %
Upon waking.	1 %	99 %	31 %	69 %
After using toilet.	0 %	100 %	54 %	46 %
Before food preparation.	5 %	95 %	29 %	71 %
Before breast-feeding.	53 %	47 %	94 %	6 %
After nappy change.	9 %	91 %	90 %	10 %
When they are dirty.	5 %	95 %	65 %	35 %
After helping child with toilet.	0 %	100 %	94 %	6 %

As the table shows the percentage of positive unprompted answers was always lower than the percentage of positive prompted answers. What was surprising was that mothers who answered the unprompted questions with "yes" did not have significantly lower faecal coliform and faecal streptococci counts than those who answered them with a "no". For example mothers who said that they washed their hands upon waking in fact had an average higher value for the FMI than those who did not wash their hands on waking, 2.6 compared to 1.7. It appears that the questionnaire did not collect accurate information on the occurrence of hand-washing, and the in depth sociological studies bear this out. The sociological study indicated a lower frequency of hand-washing than the questionnaire results implied. One explanation for the discrepancy is that mothers are often familiar with the times that they should wash their hands, but do not consider that the extra time and effort needed is warranted.

7.2 Mothers' Education

Another commonly held belief is that the higher the education of the mother, the higher the hygiene standards within her household. This statement makes two implicit assumptions, the first being that general education includes an element of health education and the second that knowledge about correct hygiene practices implies that they will be implemented.

No evidence was found from the survey that the mothers educational level was linked to the FMI, and table 2.2 shows the mean value of the FMI for mothers categorized into three levels of education. "Low" corresponds to no education at all to 3 years, "medium' corresponds to 4 to 6 years of education and "high" to 7 years of education and above.

Table 7.2: Mean FMI by mothers' educational level.

Mothers level of education	Mean FMI count
Low.	-0.01
Medium.	0.12
High.	-0.07

The similar values for the mean of the FMI indicate that mothers' education was independent of the FMI.

7.3 Family Size

The reasoning for expecting a link between family size and faecal contamination was that in a large family mothers would have less time to carry out hygiene related practices, and conditions in the home would be more cramped. However no link was found in the data as table 7.3 shows.

Table 7.3: Family size and Mean FMI Count

Family size	Mean FMI count
1 to 5	-0.09
6 to 7	0.06
8 & over	0.01

7.4 Income Level

The final variable that was thought likely to be correlated with the level of faecal contamination was wealth. This was because more wealth is often considered to go hand in hand with higher levels of education and more attention being given to hygiene enhancing activities. Another reason for expecting a link between hygiene and education is that the process of education might make one more receptive to "new ideas', one of these ideas being improved hygiene behaviour. The study provided no evidence for this hypotheses. Wealth was measured during the interview by a number of "wealth indicators". These were a car, a radio and a bike. The number of car owners was negligible but the bike and radio owners were more evenly distributed between the "have's" and the "have not's", and table 7.4 shows the mean FMI for families with and without radios and bikes.

Table 7.4: Wealth Indicators and the FMI

Wealth indicator	Mean FMI count	Number of cases
Radio.	-0.07	24
No Radio.	0.03	49
Bike.	0.08	25
No Bike.	-0.03	49

The similar counts for the FMI between groups indicates that "wealth" as measured by these indicators does not influence the level of hygiene in a family.

Other factors which may have influenced bacterial counts but which were not explored are discussed in section 9.3.

8 Comparing the Three Washing Methods

8.1 Difficulties in Comparison

Comparison of the three hand-washing methods, traditional, soap and mukombe is hampered by the fact that they were all carried during different times of the year, and it has been established that seasonality contributes to bacteria counts. However the effect of the seasonal variation was not considered important enough to warrant a transformation of the microbiological data that would take seasonality into account.

As mentioned in section 5.2, the counts for the mukombe are subject to exaggeration because of the contaminated water used for this part of the hand-washing. The values given in Table 8.1 are the transformed values for the mukombe data.

8.2 The Microbiological Counts

In order to compare hand-washing methods the raw data was logged, because this transformation irons out some of the intrinsic problems associated with the data (see annex A3). Only the information obtained from the first hand-washing is used because it is considered the best indicator of the effectiveness of any one method.

The raw counts (before the log transform) of the three different methods are given in table 8.1. In addition the control group data for the mukombe method is included. This control group data is comparable to the traditional hand-washing data, but is used as a control for the mukombe part of the study because the major emphasis of the research project was on the mukombes themselves. By using a control while testing the mukombe, it was hoped that the problem of seasonality could be partially overcome.

Table 8.1 Mean bacteria counts by Method used.

		Faecal Bacteria	
Method		Coliform	Streptococci
Traditional		56	298
Soap		164	564
Mukombe	Case	125	481
	Control	58	349

Table 8.2 shows the mean logged counts for the three different methods, and it is these figures that will be used to compare hand-washing methods.

Table 8.2 Mean logged bacteria counts by Method used.

		Faecal Bacteria	
Method		Coliform	Streptococci
Traditional		2.38	4.79
Soap		4.09	5.89
Mukombe	Case	2.71	5.70
	Control	2.01	5.10

Table 8.2 clearly shows that soap is the most effective method of hand-washing followed by the mukombe, and traditional hand-washing is the least successful of all. The three methods are statistically significantly different (Kruskal-Wallis test $p<0.0001$ for both faecal coliforms and faecal streptococci). This gives a strong indication that traditional mukombe and soap hand-washing are significantly different in their effectiveness at removing bacteria from hands.

Comparing the case/control study for the mukombe data is not easy because of the small sample sizes involved (about 45 in each group). Consequently the power of any test used is low, and because of the high variability of the data, and especially the concentration of data points around "0" for the faecal coliform counts, tests are likely to be unreliable. Bearing these facts in mind a 2 Sample Kolmogorov-Smirnov test gives a significance level of 0.18 for faecal coliform counts and <0.001 for faecal streptococci. This gives very strong evidence that the faecal streptococci counts for the mukombe and control hand-washing methods have different statistical distributions, and on inspection of the data the conclusion to be drawn is that the mukombe washes off more faecal streptococci than the control method. The figure of 0.18 is too high to say that a "significant statistical difference" exist for faecal coliforms from the case/control study, but given that only about 50% of the data was not equal to zero in value, the fact that the test does not show a significant difference is not surprising. A look at the raw means for the 2 methods, 125 for the mukombe hand-washing and 58 for the control method indicates that the mukombe <u>is</u> effective at washing off faecal coliforms.

When dealing with significance levels there are 2 related ideas that must be understood. The first is that simply because a statistically significant difference does exist between 2 populations, it does not necessarily follow that this difference is of any importance, and secondly even if there is <u>no</u> "significant" difference it does not necessarily follow that the difference that does exist is unimportant.

9. Discussion

9.1 Factors Which Influenced Bacterial Counts

As briefly described in Chapter 6 of this report several factors seem to have an influence on whether or not people have high counts of faecal coliforms and faecal streptococci on their hands. These factors are:
-humidity
-the area where the person lives
-whether or not there is an infant in the family
-the persons age
-the person's activity immediately before hand-washing

These factors will be considered in turn below:

9.1.1 Humidity

As stated previously humidity is positively correlated with both faecal coliform and faecal streptococci counts. As humidity is essential for bacterial growth, it makes sense that on days of high humidity the counts were higher as hands are probably moister, and generally conditions are damper. It was hoped that this finding could be related to peak times of diarrhoea in Zimbabwe. However information in this area seems to be scanty and only derived from hospital data. It appears that diarrhoea in Zimbabwe peaks from September-January, and is lowest in February-June. But this varies from area to area and year to year (UNICEF, 1985). If there are more faecal indicator bacteria on the hands in times of high humidity it follows that there may also be more pathogenic bacteria of faecal origin during times of high humidity. This finding is relevant because it could possibly be included in a health education programme. The message being, that during the rainy season and times of high relative humidity it is even more important to wash hands as this is the time of highest risk. Health education messages could have a seasonal bias related to these times of high risk. Fortunately, this is also the time of year when the most water is available which would make hand-washing that much easier.

9.1.2 Area

Those people living on commercial farms have significantly higher numbers of faecal indicator bacteria on the hands than people living in the peri-urban area and in the rural area. The reasons for this are numerous. First of all, it is important to consider the standard of living on commercial farms. In a recent study, people living on commercial farms were found to live in very crowded conditions, with up to 30 people/acre, making these areas more densely populated than people living in rural areas, on mines or in urban areas. Also, people living on commercial farms live at the lowest level of poverty of these four groups, according to the same study (Loewenson, 1986). Apart from the factors listed above other reasons for the high counts include the upheaval in social structures that must occur when families move away from their traditional home and their extended families. The support, as well as pressure to conform to traditional hygiene behaviour may no longer be present on the farms. Mothers receive virtually no support and help with childcare as fathers are often gone for large parts of the day. No other relatives are usually present to help with household activities and childcare. On top of this many mothers are also involved in casual work on the farms to add to the family income and so may have less time to attend to hygiene within the family. Another factor to consider is the close proximity of the farm compounds to many animals which are a major source of bacterial contamination. Although families in rural areas also have animals, such as cattle, these are usually kept quite a distance from the actual houses.

These findings are very important in view of the fact that 20% of the population of Zimbabwe live on commercial farms.

Apart from improving the standard of living on commercial farm compounds, including enough water taps and toilets, hygiene education programmes could be implemented. These programmes must bear in mind the mother's limited time as well as financial resources.

The village used may also not be typical of rural villages in Zimbabwe. First of all due to its close proximity to Harare, many families have a salaried worker contributing to the family income, possibly making this a wealthier than average village. Secondly, this village has a Village Health Worker who is very well liked by the community and appears to be quite successful in initiating new ideas. One example of this is hand-washing after using the toilet. This is not considered to be a traditional practise yet a few families in this village do practise it. It is thought that the Village Health Worker has been instrumental in starting this behaviour.

9.1.3 Infants

Having an infant in the family was shown to increase the counts on all family members hands but in only two of the three areas. In the rural area having an infant in the family actually decreased on average the counts on family members' hands. Again, mothers living in a traditional environment have more support systems to cope with caring for infants and young children. Also, there is some pressure to conform to traditional hygiene behaviour as well as new ideas, such as washing hands after using the toilet an idea that has been accepted by the community as a whole. Women living in rural areas may also have more time to contribute to hygiene practises than women living in the peri-urban area and on the commercial farms, as women in these areas are often engaged in other activities to increase the family income. Families with infants could be targeted for special attention in a hygiene education programme, with emphasis on behaviours such as nappy changing which can lead to faecal contamination of the hands.

9.1.4 Age of the person

Of the three categories defined: mothers, children 0-5 years old and children 6-12 years old, mothers and young children have the most faecal contamination on their hands. Reasons for this include must include that children 6-12 years attend school and are often washed thoroughly before leaving home. Also mothers are involved in a variety of activities which may lead to faecal contamination of the hands including changing nappies, food preparation, applying cow dung to floors, etc. As for young children, their hygiene practises are known to be far from ideal and may include touching numerous items on the ground and frequently touching faeces and animals. Again mothers must be made aware of those behaviours which can contribute to contamination of the hands, particularly hygiene behaviours of young children.

9.1.4 Persons activity

From table 6.8 in Chapter 6, it is obvious that some activities are "dirtier" than others. As already described in Chapter 6 the activity that a person is doing immediately before washing has an effect on the bacterial counts. And also as previously stated people involved in outdoor physical activities have the highest counts on their hands. These activities include gardening, chopping wood and feeding chickens. People should be made aware that these are activities likely to cause contamination on the hands. Therefore hand-washing after such activities is especially important.

People involved in activities using water, such as bathing children, washing clothes and washing dishes had low counts. This is surprising as the water would probably be quite contaminated bacteriologically from the child's body, the dishes or the clothes. Perhaps water affects the "stickiness" of bacteria, referred to in section 5.5. Bacteria may adhere to the skin much more easily in a dry environment provided the hands are moist enough, than when placed in water.

9.2 Factors Which Did Not Influence Bacterial Counts

9.2.1 Prompted and Unprompted Questions

As stated in section 7.1, it appears that the information gathered from the questionnaire with regard to times that hands are washed is unreliable. Mothers appear to have an idea that hand-washing is important at different times of the day but they do not necessarily wash their hands at those times. This is the major reason for including observations of families in this study. Since a questionnaire did not provide accurate information concerning hand-washing times, accurate information could only be obtained through observation. These findings will be discussed in section 9.4.

9.2.2 Other Factors

Of the other factors mentioned in Chapter 7 perhaps the most interesting finding is that the mother's education was independent of the FM1. Hygiene behaviour in many cultures is mostly learned in the home and passed down from generation to generation. Also formal education may lack an effective health education message with regard to personal and domestic hygiene. Both are possible explanations for this finding.

9.2.3 Stored Water

An aspect, not mentioned in Chapter 7 is the stored water count for each household. The mean number of faecal coliforms is 131/100ml and of faecal streptococci is 205/100ml. High counts on hands were not correlated with high counts in stored water. However, stored water in the household is not necessarily that used for hand-washing.

9.3 Factors Which May Have Influenced Bacterial Counts But Were Not Explored:

Several factors may possibly have been correlated to high counts in certain families but were not explored for various reasons. In most cases not enough information was gathered to attempt the correlation.
These factors include:
1. Wealth Index
2. Distance to Water Source
3. Water Quantity
4. Knowledge of Importance of Hand-washing
5. Omission of Questions

9.3.1 Wealth Index

Originally it was hoped to calculate a wealth index for each family. First it was difficult to approximate the monthly earnings of a family. For example a traditional healer could earn a monthly wage which varies considerably from person to person. Therefore families were not able to be grouped into categories with regard to income as originally hoped. The only realistic comparison was between salaried versus unsalaried workers.

A salaried worker being one earning the minimum wage of ZW$160/month and not including domestic servants and farm labourers who have a lower minimum wage (ZW$100 or less/month). There was no difference in bacterial contamination of the hands between families with and without a salaried worker. Another indicator of wealth which was omitted was the number of cattle and other animals each family owned. However, this and house type were specific to rural areas and possibly Epworth but could not be used on the farms where people owned relatively few animals and whose houses are built for them. Other factors which could have been included in a wealth index were possession of a radio or bicycle which were explored in section 7.4.

9.3.2 Distance from Water Source

As distance from water source was so closely correlated with area, it was not possible to look at this as an independent variable. The rural area, which had traditional unprotected wells and an average distance to source of about 500m had the lowest counts. The farms in contrast where the mean distance was approximately 100m had the highest counts. This once again shows that provision of water is not enough. In western countries where water is often abundant and close by, people, especially children do not necessarily wash their hands after using the toilet. Health education as to the importance of hygiene is a vital component as well as the provision of water supplies and sanitation facilities.

9.3.3 Water Quantity

Again insufficient information was collected to determine how much water was used per family per day. If more water was available in the family compound hand-washing would be more convenient but not necessarily done. Average consumption in Zimbabwe is 76.1 l/day. When families live 30m away, the amount is 122 l/day, when 30m-3km it is 78 l/day and when 3km or over it is 67 l/day (National Master Plan, 1985, vol. 4.2). The families in this study were mostly in the 30m-3km range.

9.3.4 Exploration of Importance of Hand-washing

Many mothers suggested from their responses to the questionnaire that they wash hands frequently. When asked why hand-washing was important only 47% mentioned to prevent diseases. This indicates a failure in health education programmes to get the message across as to exactly why hand-washing is so important. In another study only 6% of mothers saw poor hygiene as a cause of diarrhoea (UNICEF, 1985). Again the relationship of hygiene to diseases, particularly diarrhoeal must be emphasised. It was not possible in this study to explore the relationship between the counts on peoples hands and the mother's perception of the importance of hygiene.

9.3.5 Omission of Questions

A few questions were also omitted from the analysis such as what adults use for anal cleansing due to embarrassment. Also omitted was the state of the internal water storage container because it was difficult to see inside the container in the dark kitchen and mothers were reluctant to allow the container to be taken outside. In future studies more culturally acceptable ways of obtaining this information would have to be explored.

9.4 Unreliability of Hygiene Information Gathered:

As previously stated, it was thought that the hygiene information gathered was unreliable. What people say they do and what they actually do are often not the same thing.

To determine what hygiene behaviour actually occurs in the family two students from the University of Zimbabwe observed eight families. Unfortunately Epworth was omitted from this exercise due to illness on the part of the third student. Four families on the farms and four families in the village were observed for 2-3 days each. One must bear in mind that some of the information was difficult to gather especially as the students were relatively inexperienced with regard to field work. They were also unsupervised for the most part while the field work was taking place. However, despite these limitations some interesting information was gathered.

9.4.1. The Village:

In this village several hygiene behaviours appeared to take place almost without exception.
1. Hands and face were washed first thing in the morning.
2. Hands were washed before and after meals including tea.
3. Mothers in most families washed their hands before and during food preparation.
In one of the four families hands were regularly washed after using the toilet and occasionally in another. Also, hands were sometimes washed after assisting a child to use the toilet and after cleaning the floor. The information on bathing is possibly inaccurate as the student was not present from dawn till dusk. She reports only one of the four bathing on a daily basis, while another study reports 80% of people bathing daily (National Master Plan, 1985, vol. 4.2).

9.4.2 The Farms

On the whole there appeared to be less washing on the farms:
1. Generally hands were washed before meals but this was not always done by children. Not every family washed their hands after meals. In addition hands would not always be washed before eating foods between major meals.
2. Washing in the morning did not always occur, this was especially true of children.
3. Hands were sometimes washed before food preparation.
4. In one case it was observed that hands were not washed even after changing a nappy.
No information was gathered with regard to hand-washing after the toilet. Bathing did not seem to be an every day occurrence in all families.

Although the students did not gather much information concerning bathing it obviously did not occur as often as mothers suggested on the questionnaire. Also hand-washing was not as common an occurrence as was suggested by the responses to the hand-washing questions. The observation that hands were washed less frequently on the farms could be one explanation for the higher counts there. But to draw any accurate conclusions, observations on more families with more information would need to be gathered.

9.5 Comparison of the Three Methods

The difficulties and limitations with comparing the three methods were explained in Chapter 8. All three methods remove faecal bacteria from the hands. Washing with soap appears to be the most effective, closely followed by washing with the mukombe with traditional hand-washing being the least effective. Washing with soap involves more rubbing to get the soap off than traditional hand-washing. So whether the greater efficiency of washing with soap in removing faecal bacteria from the hands is due to using soap or more vigorous rubbing is not clear. Past research has shown that washing with soap is marginally more effective than washing with water alone. The most important things are the amount of time spent washing and the vigour involved (Lowbury, et al. 1964 and Sprunt, et al. 1973).

However using soap may be easier to implement than increasing the washing time in a health education programme. The major obstacle is the price and availability of soap in Zimbabwe. Using the mukombe also involves more rubbing with the added effect of water actually helping to rinse the bacteria off. This could be one reason for the greater efficiency of washing with the mukombe over traditional hand-washing.

Another limitation with comparing the three methods involves the actual counting of the bacteria. Although the numbers give an indication of the degree of contamination on the hands, they are probably an underestimate. In most cases the second hand-washing contained faecal bacteria so there was certainly bacteria remaining on the hands after the first wash. In order to get a more accurate idea of the actual number of faecal bacteria on the hands, a series of hand-washings would have been needed,not just two. Past studies bear this out (Price, 1938). Also, many bacteria may have died during the filtration process and plating on the harsh selective media needed to isolate these specific bacteria. In the case of hand-washing with soap, the soap may have had germicidal properties. Even with these limitations however it is felt that enough faecal bacteria were isolated so that the three methods could be compared.

9.6 Acceptability of the Mukombe

It is difficult to determine accurately whether or not the mukombes are culturally acceptable and whether or not they are being used. All mothers said they liked the mukombe Over 30% of mothers said that it made hand-washing convenient. Often family members who want to wash their hands are hampered because they must first locate a dish and some water with which to do so. From observations made at each household it appears that about 58% of the mukombes are in regular use. As only a brief discussion was held with the family when giving them the mukombe, it is possible that this figure would be far higher if an intensive health education programme was implemented concerning the importance of washing hands and the use of the mukombe. 50% of mothers were prepared to pay Z$5.25 for the mukombe. As the cost to manufacture one is Z$8.00 it is possible that people will not be prepared to pay the extra cost. This aspect will have to be explored further.

9.7 Suggestions for Future Work

From the discussion above, it is obvious that there is tremendous scope for future work in the field of hand-washing. Some suggestions for research and health education programmes are as follows:

1. To look at pathogens on the hands. No information was gathered in this study about the presence of pathogens, only faecal indicator bacteria, and they may be different.

2. To explore whether or not high counts on hands are associated with more diarrhoea in a family.

3. To determine whether or not the introduction of the mukombe decreases the incidence of diarrhoea in those families who use it.

4. To gather more information on traditional hand-washing in the family setting. Is traditional hand-washing a possible method for the spread of pathogens? Would the mukombe as an alternative be acceptable and decrease the incidence of diarrhoeal diseases?

5. To determine the extent to which diarrhoeal diseases are spread among family members and how hand-washing might alter this.

7. To include in research and health education programmes infant handling risks. For example changing nappies can grossly contaminate the hands.

8. To more fully explore risk activities, and include them in health education programmes.

9. To determine ways in which health education programmes can be made more successful by stressing why hand-washing is important.

10. To use observation to a greater extent to pin point specific behaviours which may be responsible for higher or lower counts on the hands. From this study, it appears that a questionnaire alone does not provide accurate information concerning personal and domestic hygiene.

One of the major findings in this study is that the three methods of hand-washing decrease the number of faecal bacteria on the hands. This opens the door for future research programmes which must address the question of whether or not increasing hand-washing reduces the incidence of diarrhoea in Zimbabwe.

References

BLACK,R.E., DYKES, A.C., ANDERSON, K.E., WELLS, J.G., SINCLAIR, S.P., GARY, G.W., HATCH, M.H., GANGARPSA, E.J. (1981): Handwashing to Prevent Diarrhea in Day-care Centers, American Journal of Epidemiology, 113, 445-451.

CLEMENS,J.D. and STANTON, B.F. (1987): An Educational Intervention for Altering Water-Sanitation Behaviours to Reduce Childhood Diarrhea in Urban Bangladesh, American Journal of Epidemiology, 125, 284-300.

DeZOYSA, I., CARSON, D., FEACHEM, R., KIRKWOOD, B., LINDSAY-SMITH, E., Loewenson, R. (1984): Perceptions of Childhood Diarrhoea and Its Treatment in Rural Zimbabwe, Soc.Sci.Med. 19, 727-734.

DHSS et al. (1982): The Bacteriological Examination of Drinking Water Supplies, 5th edn. (Department of Health and Social Security, Department of The Environment and the Welsh Office: Reports on public health and medical subjects No. 71). London, HMSO.

DRASAR, B.S. and BARROW, P.A. (1985): Intestinal Microbiology , Wokingham, England, Van Nostrand Reinhold (UK) Co. Ltd.

FEACHEM, R.G. (1983): Sanitation and Disease, London, John Wiley.

FEACHEM, R.G. (1984): Interventions for the Control of Diarrhoeal Diseases Among Young Children: Promotion of Personal and Domestic Hygiene, Bulletin of the World Health Organization, 62. 467-476.

KHAN, M.U. (1982): Interruption of Shigellosis by Hand Washing, Transactions of the Royal Society of Tropical Medicine and Hygiene, 76, 164-168.

KOOPMAN, J.S., (1978): Diarrhea and School Toilet Hygiene in Cali, Columbia, American Journal of Epidemiology, 107, 412-420.

LOEWENSON, R. (1986): Farm Labour in Zimbabwe: a Comparative Study in Health Status, Health Policy and Planning 1, 48-57.

LOWBURY, E.J.L., LILLY, H.A., BULL, J.P. (1964): Disinfection of Hands: Removal of Transient Organisms, British Medical Journal, 2, 230-233.

LOWBURY, E.J.L. (1969): Gram Negative Bacilli of the Skin, British Journal of Dermatology supplement 1, 81, 55-61.

MEWRD (1985): National Master Plan for Rural Water Supply and Sanitation, Ministry of Energy and Water Resources and Development, Interconsult A/S, NORAD, volume 4.1 (Outline of a Health Profile).

MEWRD (1985): National Master Plan for Rural Water Supply and Sanitation, Ministry of Energy and Water Resources and Development, Interconsult A/S, NORAD, volume 4.2 (Social Studies).

PETHER, J.V.S. and GILBERT, R.J. (1971): The survival of Salmonellas on Fingertips and Transfer of the Organisms to Foods, Journal of Hygiene, 69, 673-681.

PRICE, P.B. (1938): The Bacteriology of Normal Skin, A New Quantitative Test Applied to a Study of the Bacterial Fora and The Disinfectant Action of Mechanical Cleansing, Journal of Infectious Diseases, 63, 301-318.

SPRUNT, K., REDMAN, W., EIDY, G., (1973): Antibacterial Effectiveness of Routine Hand Washing, Pediatrics, 52, 264-271.

STEERE, A.C., MALLISON, G.F. (1975): Hand Washing Practices for the Prevention of Nosocomial Infections, Annals of Internal Medicine, 83, 683-690.

STUTTARD, L.W. (1961): Release of Bacteria from Surgeons' Hands, British Medical Journal, 2 , 591.

UNICEF (1985): Children and Women in Zimbabwe: A Situation Analysis, Government of Zimbabwe.

WORLD BANK (1983): Zimbabwe Population, Health and Nutrition Sector Review, Population Health and Nutrition Department, Report No. 4212-Zim.

Photo 1: Traditional Handwashing

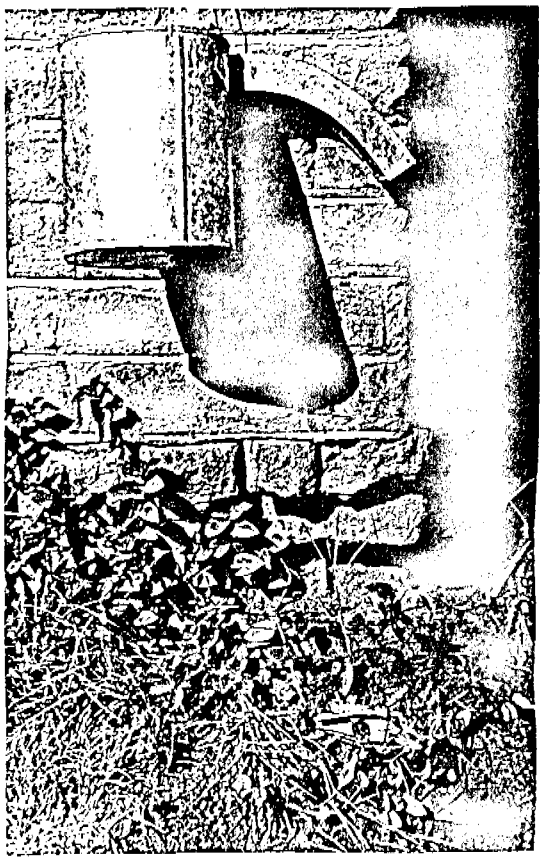


Photo 2: The Mukombe

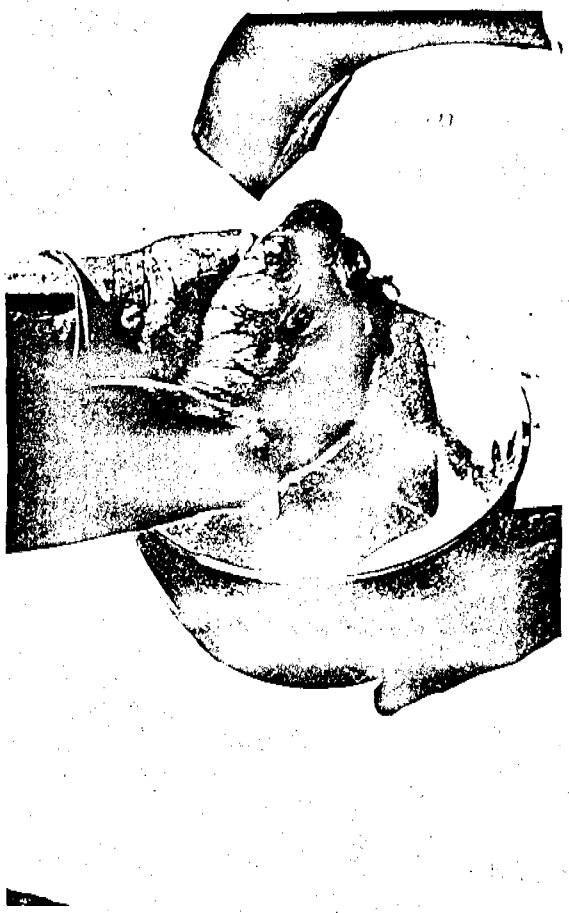


Photo 3: Mukombe Hand-Washing

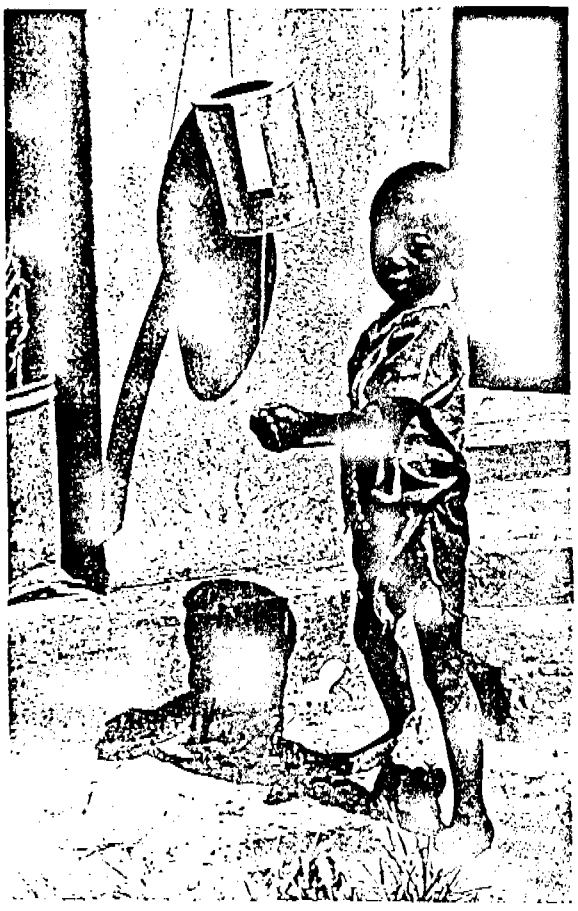


Photo 4: Using the Mukombe

Table of Contents for Annex A1

Notes for Traditional Hand-Washing Questionnaire:
Initials: the person asking the questions should fill in his/her initials in this space.
Date: day/month/year
Time: hours:minutes
Area: put a check ( ) next to either Epworth, commercial farm or VIDCO, then if it is a commercial farm or VIDCO insert the name of the farm or the name of the village in the appropriate space.
Household Name/Number: in Epworth use the household number and on commercial farms and in villages use the family name.

Make sure EACH question is asked of each mother. There should be only ONE answer checked unless there is an indication in these notes that there may be more than one answer. If more than one is given when there should be only one then ask which is the most common and check just that answer.

Q1 Ask as written. Adults include all men, women and children over 12 years of age living in this home. A "home" is defined as all houses which share a common kitchen in villages. In Epworth it is family members only and not lodgers whether or not they share a kitchen. On a commercial farm it includes those family members living with the farm worker only.

Q2 All mothers, children and grand mothers living in this home are to be listed, whether or not they are actually present. Put them in family groups so that the mother is listed first and then her children, then the next mother and then her children. Make sure to include any children who are away or at school or in the fields as well as mothers who are away. Each person is given a number which is used on their hand-washings bottles. The sex, age and mother's name are only for children. List what each person is doing immediately upon our arrival (playing, eating, washing up, etc.).

Q3 This and the rest of the questions should be asked of the woman who normally cares for the children. Her name should be written in the space marked "name".

Q4 Ask as written and put a check ( ) next to each one mentioned. Don't give any suggestions. There may be more than one answer mentioned and each one should be checked. Q5 Ask as written.

Q6 Ask as written. Comment if it doesn't make sense, next to the question.

Q7 Ask as written. Any adult literacy, etc. goes under "any other training", (put a check next to any other training and write what training in the space which says specify). There may be more than one answer.

Q8 Ask as written, being sure to fill in the name of the cooperative, club or association where applicable.

Q9 Ask as written. If there is no husband, then fill in the reason why (divorced, widowed, single, etc.) in the space next to no husband.

Q10 Ask as written. If a salaried worker or absent worker (one who sends money home) then give the specific job title. Hopefully this will give an idea of the income of the family. There may be more than one answer. Mention any way the family earns or receives money.

Q11 Start with the season we are in and ask where she gets water for bathing and clothes washing. Then ask the other season, drinking/cooking first then bathing/clothes wasshing. Make sure to fill in all four even if the same water source is used for all four. Also make sure to fill in the distance from the main house of each water source.

Q12 The purpose of this question is to get an idea of how much water is used each day for cooking, drinking, washing dishes and bathing. Other activities such as making beer are not done every day and so are not included. Ask how many people collected water yesterday (for cooking, drinking, washing clothes, bathing and dishes), list their names, their relationship to the mother (for mother put an x in this section) and how many trips each person made. Add the trips each person made to get the total number of trips made to collect water.

Q13 Ask as written. The water stored last night.

Q14 Ask as written.

Q15 Ask as written.

Q16 Ask as written.

Q17 Ask as written.

Q18 Ask as written, this refers to children within this family.

Q19 Ask as written and insert a number in the box. This question is different from Q21. This question refers to the age when the child actually goes off by him or herself to the toilet. He/she may still need help with anal cleansing.

Q20 Ask as written, this refers to children who no longer wear nappies, in this family.

Q21 Ask as written and insert a number in the box This question refers to the age when children need no help whatsoever in using the toilet.

Q22 Ask as written.

Q23 Ask as written, refers to any child presently at an age who would use nappies.

Q24 Ask as written.

Q25 Ask as written, refers to today only.

Q26 Ask as written, washing refers to any washing involving more than just the hands.

Q27 Ask as written, washing is as in Q26.

Q28 Ask as written, washing is as in Q26.

Q29 Ask as written.

Q30 Ask as written.

Q31 Ask as written.

Q32 Ask as written, refers to the age when children need no help with actually washing themselves. They may still need help with getting the water.

Q33 Ask as written.

Q34 Ask as written.. Give as many reasons as the woman says.

Q35 "Do you wash your hands each day...." Ask each answer and put a check if she says yes and a x if she says no. "Sometimes" gets a check.

OBSERVATION

1. Make sure to check roof, walls and floor.

2. Measure the length, width of each building used for sleeping, including the kitchen if it is used for sleeping. If the building is circular, measure the circumference.

3. Look for a radio, bicycle and car and ask.

4. List any water sources which might be used which are not mentioned in the previous section. Look out especially for traditional wells.

5. Actually look at the water storage container.

6. Look inside the water storage container.

7. If there is a lid but it is not on the container the answer is still "no".

8. The size of the container used to carry the water from the source.

9. The size of the container in which water is stored. Be sure to list each one used for storing water for drinking/cooking. The water storage container and the water collection container may be the same thing.

10. Refers to containers of water stored for other purposes.

11. Look inside to see if the container looks clean.

12. Ask to make sure if you don't see any.

13. My be more than one answerer

14. As written.

15. Actually look at the plate drying rack and note where it is (on a brick, on the chicken coop, etc.).

16. Look closely at the toilet.

17. Go inside the toilet to check condition.

18. May be more than one answer.

19. Ask to see where the nappies are at the present moment. If they are all on the line, write "on the line".

20. As much information regarding flies as possible should be included.

21. As written.

22. Anything else of importance for example religion (Muslim, Apostolic Faith, etc.). Also any other signs of income generating activities (beer brewing, etc.).

Initials: _____

Date	Time

AREA	
Epworth	
Commercial farm (specify)_____	
VIDCO (specify)_____	

Household Name/Number

1. How many adults live in this home?

2. Children in this home 12 years or younger, and mothers, grandmothers:

No.	Name	Sex	Age	Mother's name	location	person is doing what?

THE FOLLOWING QUESTIONS ARE TO BE ASKED OF EACH MOTHER

I. General Information

3. Who is answering the questions?

mother	
grandmother	
other female relative (specify)	

Name: _____

4. When do you wash your hands each day?

before meals	
first thing in the morning	
after using the toilet	
before food preparation	
before breastfeeding	
after changing nappies	
when they are dirty	
after assisting child/infant with toilet	
other (specify)	

5. How long have you lived here?

since birth	
more than 10 years	
1-10 years	
under one year	

6. Where were you born?

Zimbabwe, district _____	
outside Zimbabwe, country _____	

7. Number of years of schooling for the mother?

1-3 years	
4-6 years	
7-10 years	
over 10 years	
no formal education	
any other training (specify)	
don't know	

8. Is the mother a member of a:

cooperative (specify)_____	
Women's club (specify)_____	
Women's association (specify)_____	
No women's groups	

9. Number of years of schooling for the husband?

1-3 years	
4-6 years	
7-10 years	
no formal education	
any other training (specify)	
Don't know	
No husband	

10. What are the family sources of income?

agriculture	
livestock	
salaried worker (indicate job title)	
absent worker (indicate job title)	
other (specify)	

II. Domestic Hygiene and Water Supply

11. Type and distance of water supplies:

	Protected well	Unprotected well	tap	other (specify)	distance (metres)
wet season drinking/cooking					
wet season bathing/clothes washing					
dry season drinking/cooking					
dry season bathing/clothes					

12. Number of trips made to collect water for this family/room yesterday:

Person's name	relationship to mother	number of trips

Total number of trips:_____

13. How much water did you store overnight last night?

full storage container	
½ storage container	
⅓ storage container	
⅔ storage container	
no water	

14. How often do you wash dishes each day?

once	
twice	
three times	
four or more times	
don't wash dishes every day	

15. Do you use soap for washing plates?

always	
never	
sometimes	

III. Personal Hygiene

16. Where do you dispose of childrens' faeces?

in latrine	
bush	
rubbish pit	
river	
other(specify)	

17. Where do you dispose of infants' faeces?

in latrine	
in bush	
rubbish pit	
river	
other (specify)	
no infant	

18. Do children use the latrine?

No latrine	
all children use	
only children over a certain age _____	
other	

19. At what age do children go to the toilet by themselves?

20. What do small children use for anal cleansing?

toilet paper	
newspaper	
leaves	
other(specify)	

21. Up to what age do children need assistance with anal cleansing?

22. What do you use for anal cleansing?

toilet paper	
newspaper	
leaves	
other (specify)	

23. Do you use nappies?

yes	
no	
no children at an age to use nappies	

24. Where do you put nappies after use?

washed immediately	
in a dish with water	
in a dish without water	
don't use nappies	
no child in nappies	
other (specify)	

25. Do you have a bar of soap for body washing today?

yes	
no	

26. How many times do you wash yourself each day?

once	
twice	
three times	
more than three times	
don't wash every day	

27. How many times do children wash each day?

once	
twice	
three times	
more than three times	
don't wash every day	

28. How many times each day are infants washed?

once	
twice	
three times	
more than three times	
don't wash every day	
no infant	

29. Where do the adults bathe?

river	
bathroom	
toilet	
courtyard	
inside house	
other (specify)	

30. Where are children washed?

river	
bathroom	
toilet	
courtyard	
inside house	
other (specify)	

31. Where are infants washed?

river	
bathroom	
toilet	
courtyard	
inside house	
other (specify)	
no infant	

32. How old are children before thwy go and wash themselves?

33. Do you think hand-washing is important?

yes	
no	

34. If yes, why?

35. When do you wash your hands each day:

before meals	
first thing in the morning	
before going out shopping	
after using the toilet	
before dressing the children	
before food preparation	
Before breastfeeding	
before changing nappies	

35. (continued)

after changing nappies	
when they are dirty	
after assisting child/infant with toilet	
before washing plates	
before drying plates	

OBSERVATION

1. House style:

ROOF	
thatch	
iron	
asbestos	
other	

WALLS	
pole & daga	
cement blocks	
brick	
plastered	

FLOORS	
cement	
daga	

2. Square meterage of sleeping quarters:
(list length and width of each building used for sleeping or the circumference for circular buildings.)

3. Does the household have;

radio	
bicycle	
car	

comment on other signs of wealth:

4. Any evidence of other water sources not mentioned in the previous section:

5. What is the internal water storage container made of?

plastic	
metal	
earthenware	

6. Does the internal water storage container look clean?
(sediment, turbidity, objects floating?)

7. Is the internal water storage container covered?

yes	
no	

8. What is the size of the water collection container?
(list the size of each in litres)

9. What is the size of the water storage container? (in litres)

10. Is there any other water storage container?

yes	
no	

11. Comments on the state of other water storage containers:

12. Are there any animals around in the compound?

yes	
no	

13. If yes, what?

dogs	
goats	
chickens	
cats	
others (specify)	

14. Do they go into the kitchen?

yes	
no	

15. Is there a:

plate drying rack with good drainage	
plate drying rack with poor drainage	

comments on location of plate drying rack or where plates are put:

16. Is there a:

Blair toilet	
open pit toilet	
attempted Blair toilet	
no toilet	
toilet shared with neighbour	

17. Comments on cleanliness of toilet:

18. Are there any of the following materials used for anal cleansing present in the toilet?

toilet paper	
newspaper	
leaves	
stones	
none	
water	
other (specify)	

19. Where are nappies put after use

washed immediately	
in a dish with water	
in a dish without water	
no child in nappies	
don't use nappies	

20. Are there flies present? (comment on possible sources, whether numbers are significantly high or low or unnoticeable)

21. Weather conditions:
(presence of rain, temperature, wind)

22. ANY OTHER COMMENTS:

9. When is it used? (unprompted)

after toilet	
before food preparation	
before meals	
after changing nappies	
after meals	
from gardens	
other times	

10. Do you like it ?

yes	
no	

why or why not:

11. Do you use it for drinking?

yes	
no	

12. Do you like the location or would you prefer it somewhere else?

yes	
other location	

where:

13. Have your neighbours commented on it?

yes	
no	

14. What did they say ?

no comment	
they like it	
they don't like it	
they're jealous	

15. How much would you pay for this?

16. Cut off point_____.

D7. Do you have any ideas on how to improve it?

yes	
no	

If yes, what:

18. ANY OTHER COMMENTS:

Table of Contents of Annex A2

Table S2/1. Number of Children (Male/Female) and Adults by Area.

Area	Children			Adults	TOTAL
	Male	Female	Total		
Peri-urban	25	32	57	32	89
Farm	30	26	56	27	83
Rural	35	35	70	32	102
TOTAL	90	93	183	91	274

Chart S2/C1. Distribution of the Number of Adults in the Family.

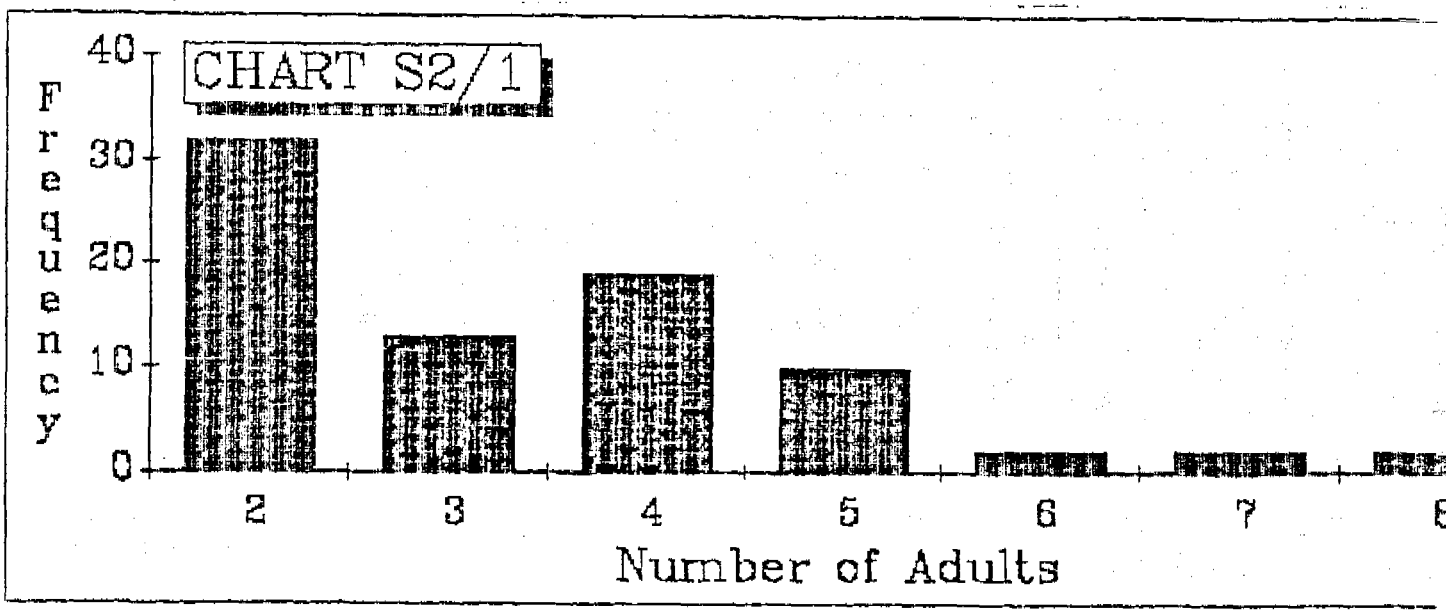


Chart S2/C2. Distribution of The Number of Children in a Family.

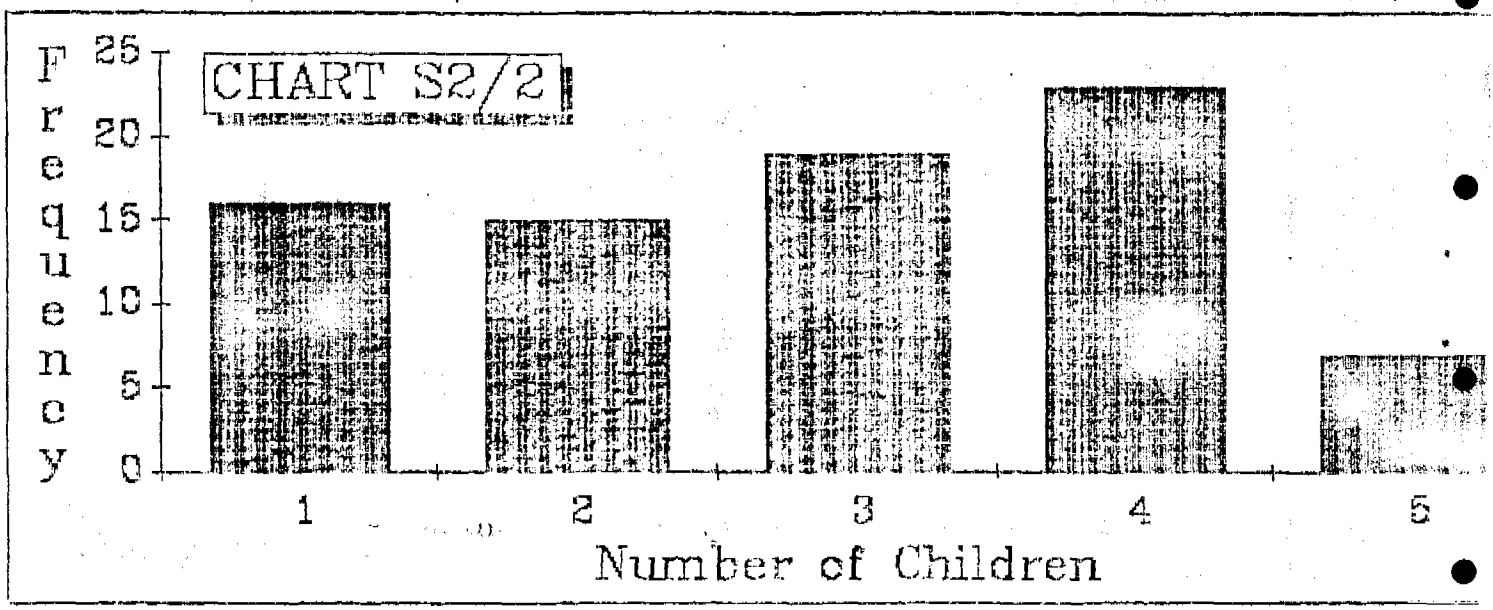


Chart S2/C3. Distribution of Family size.

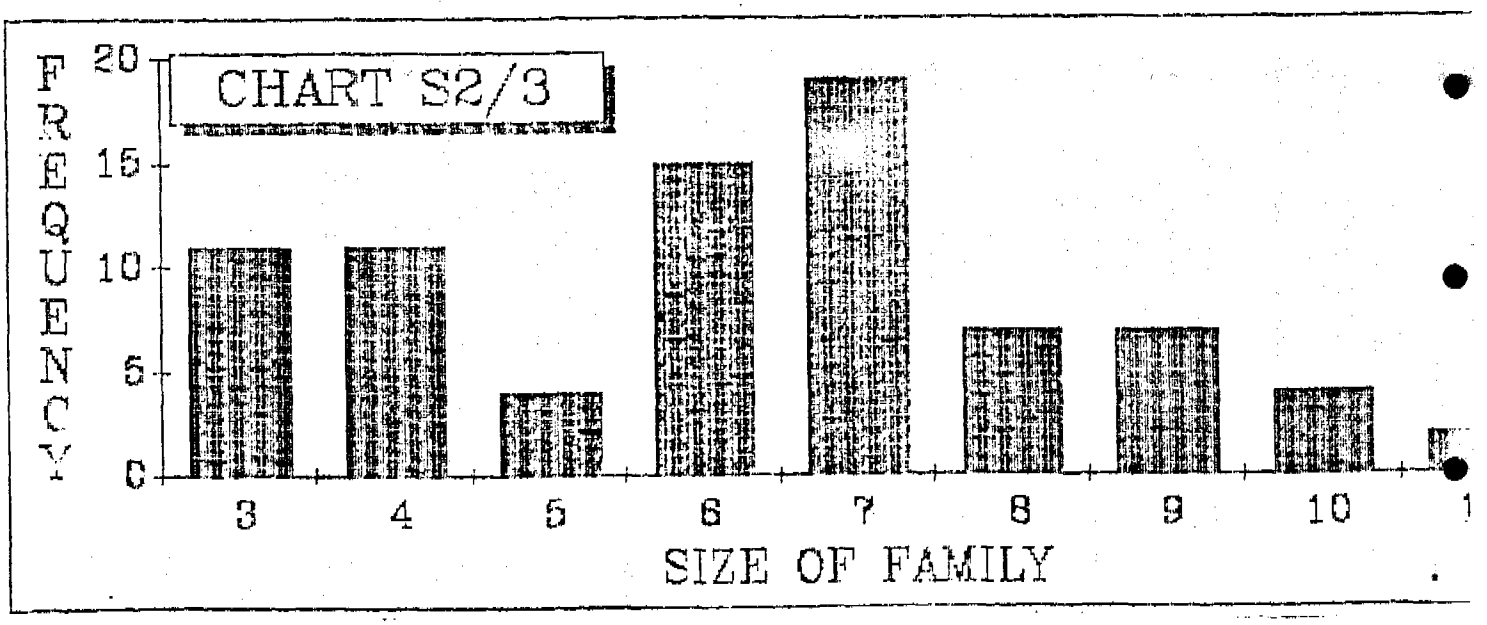


Table S2/2. Who Answered the Questionnaire.

Respondent	Mother	Grand Mother	Female Relative	TOTAL
Frequency	70	8	2	80

Table S2/3. Length of Residence of Respondent.

Category	Since Birth	More Than 10 Years	1 to 10 Years	Less Than 1 Year	TOTAL
Frequency	3	15	53	9	80

Table S2/4. Place of Birth of Respondent.

Birth Place.	Zimbabwe, Same Area.	Zimbabwe, Other Area.	Not Born In Zimbabwe.	TOTAL
Frequency	43	33	4	80

Table S2/5. Length of Mothers' Formal Education.

Years of Education	Don't Know	None	1 - 3 Years	4 - 6 Years	7 - 10 Years	More Than 10	TOTAL
Frequency	1	12	9	23	34	1	80

Table S2/6. Club Membership of Respondent.

Club	Co-op	Women's Club	No Women's Groups	TOTAL
Frequency	1	27	52	80

Table S2/7. Husbands Educational Level.

Education Level	No Husband	No Formal Education	1 -3 Years	4 -6 Years	7 -10 Years	Other Training	Don't Know	Missing Value	TOTAL
Frequency	6	4	3	12	30	3	21	1	80

Table S2/8. Wet Season Drinking Source Distance By Wet Season Drinking Source.

Distance.	Protected Well	Unprotected Well	Tap	Spring	TOTAL
< 100m.	18	5	16	0	39
100-500m.	13	13	4	4	34
500m-1Km.	3	3	0	0	6
TOTAL	34	21	20	4	79

Missing cases = 1.

Table S2/9. Wet Season Bathing Source Distance By Wet Season Bathing Source.

Distance.	Protected Well	Un-protected Well	Tap	Spring	Other	TOTAL
< 100m.	16	8	16	0	1	41
100-500m.	7	16	4	4	1	32
500m-1Km.	1	3	0	0	2	6
TOTAL	24	27	20	4	4	79

Missing cases = 1.

Table S2/10. Dry Season Drinking Source Distance By Dry Season Drinking Source.

Distance.	Protected Well	Unprotected Well	Tap	Spring	TOTAL
< 100m.	18	4	16	0	38
100-500m.	13	13	4	5	35
500m-1Km.	3	3	0	0	6
TOTAL	34	20	20	5	79

Missing cases = 1.

Table S2/11. Dry Season Bathing Source Distance By Dry Season Bathing Source.

Distance.	Protected Well	Un-protected Well	Tap	Spring	Other	TOTAL
< 100m.	15	7	16	0	1	39
100-500m.	9	17	4	5	1	36
500m-1Km.	1	3	0	0	0	4
TOTAL	24	27	20	4	4	79

Missing cases = 1.

Table S2/12. Wet Season Drinking Source Distance By Number of Water Collection Trips Made.

Distance.	1	2	3	4	5	6	TOTAL
< 100m.	3	14	14	2	3	0	36
100-500m.	0	10	13	8	0	3	34
500m-1Km.	0	5	1	0	0	0	6
TOTAL	3	29	28	10	3	3	76

Missing Observations = 4.

Table S2/13. Number of People in the Family Who Collect Water.

Number	1	2	3	TOTAL
Frequency	70	7	2	79

Missing cases = 1.

Table S2/14. Amount of Water Stored Overnight.

Quantity Stored	None Stored	1/3 Container	1/2 Container	2/3 Container	Full Container	TOTAL
Frequency	20	18	30	3	9	80

Table S2/15. Frequency of Dishwashing/Day.

Number of Times	Once	Twice	Thrice	Four +	TOTAL
Frequency	1	23	50	6	80

Table S2/16. The Use of Soap for Dishwashing.

Usage	Always	Sometimes	TOTAL
Frequency	76	4	80

Table S2/17. Disposal Place of Children's Faeces.

Disposal Place	In Latrine	Bush	Rubbish Pit	Other	No Children	TOTAL
Frequency	53	20	2	1	4	80

Table S2/18. Disposal Place of Infants' Faeces.

Disposal Place	In Latrine	Bush	Rubbish Pit	Other	No Infants	TOTAL
Frequency	26	4	5	3	42	80

Table S2/19. Materials Used For Children's Anal Cleansing.

Material	Toilet Paper	News-Paper	Leaves	Other	TOTAL
Frequency	12	50	16	1	79

Missing cases = 1.

Table S2/20. The Use of Nappies.

Usage	Nappies Used	No Nappies Used	No Child Of Nappy Age	TOTAL
Frequency	30	10	40	80

Table S2/21. What Happens To Nappies After Usage.

What Happens	Washed Immedi-ately	Put in a dish with water	Put in a dish without water	Does not use nappies	No child in nappies	Other	TOTAL
Frequency	1	18	10	1	49	1	80

Table S2/22. The Use of Soap for Body Washing?

Usage	Yes	No	TOTAL
Frequency	75	5	80

Table S2/23. Number of Times Adults Wash Each Days.

Number of Times	Once	Twice	Thrice	Four +	TOTAL
Frequency	11	54	12	3	80

Table S2/24. Number of Times Children Wash Each day.

Number of Times	Once	Twice	Thrice	Four or more	No Children	TOTAL
Frequency	21	49	5	1	4	80

Table S2/25. Number of Times Infants are Washed Each Day.

Number of Times	Once	Twice	Thrice	Four or more	No Infants	TOTAL
Frequency	9	20	6	1	43	79

Missing Values = 1.

Table S2/26. Bathing Location of Adults.

Location	River	Bath-room	Toilet	Court-yard	Inside house	Other	TOTAL
Frequency	2	29	37	2	6	4	80

Table S2/27. Bathing Location of Children.

Location	No Child	Bath-room	Toilet	Court-yard	Inside house	Other	TOTAL
Frequency	4	23	19	26	5	3	80

Table S2/28. Bathing Location of Infants.

Location	No Infant	Bath-room	Toilet	Court-yard	Inside house	Other	TOTAL
Frequency	43	5	0	12	19	1	79

Missing Values = 1.

Table S2/29. Why is Hand-washing Important?

Reason	Not Important	Disease Prevent-ion	To Clean Hands or Fingers	To Keep Food Clean	Don't Know Why	TOTAL
Frequency	3	37	15	22	1	78

Missing cases = 2.

Table S2/30. Statistics On Age Children Use The Toilet.

Statistic	Mean	Mode	Median	Max	Min	S.D.	N.
Value	3.051	3	3	7	1	1.395	78

Table S2/31. Statistics On Age Children Need No Help With Toilet.

Statistic	Mean	Mode	Median	Max	Min	S.D.	N.
Value	3.870	3	4	9	2	1.363	79

Table S2/32. Statistics On Age Children Wash Alone.

Statistic	Mean	Mode	Median	Max	Min	S.D.	N.
Value	7.797	7	8	14	3	1.890	79

Table S2/33: Prompted Responses to The Question "When do you wash your hands?".

	Response		
Activity	NO	YES	TOTAL
Before meals	0	80	80
Upon waking	1	79	80
Before shopping	23	57	80
After going to the toilet	0	80	80
Before dressing children	27	53	80
Before food preparation	4	76	80
Before breast-feeding	42	37	79*
Before changing a nappy	70	10	80
After changing a nappy	7	73	80
When hands are dirty	4	76	80
After helping a child go to the toilet	0	80	80
Before washing plates	30	50	80
Before drying plates	24	56	80

* Missing cases = 1.

Table S2/34: Unprompted Responses to The Question "When do you wash your hands?".

	Response		
Activity	NO	YES	TOTAL
Before meals	21	59	80
Upon waking	25	55	80
After going to the toilet	43	37	80
Before food preparation	23	57	80
Before breast-feeding	75	5	80
After changing a nappy	72	8	80
When hands are dirty	52	28	80
After helping a child go to the toilet	75	5	80
Other times	70	10	80

Table S2/35: House Construction Materials

Floor Style	Roof Style	Wall Style				
		Pole & Dagga	Cement Block	Brick	Plast-ered	TOTAL
Cement	Thatch	0	0	10	9	19
	Iron	0	0	9	6	15
	Asbestos	0	0	23	8	31
	Total	0	0	42	23	65
Dagga	Thatch	3	0	7	1	11
	Iron	0	0	2	0	2
	Asbestos	0	0	0	0	0
	Total	3	0	9	1	13
Tiles	Thatch	0	0	0	0	0
	Iron	0	0	0	1	1
	Asbestos	0	1	0	0	1
	Total	0	1	0	1	2
Total	Thatch	3	0	17	10	30
	Iron	0	0	11	7	18
	Asbestos	0	1	24	8	32
	Total	3	1	52	24	80

Table S2/36: Wealth Indicators.

Wealth Indicator	No	Yes	No Response	Total
Radio	51	26	3	80
Bicycle	52	26	2	80
Car	75	0	5	80

Table S2/37: Additional Wealth Indicators.

Number of Other Wealth Indicators	No other wealth indicator	1 other wealth indicator	2 or more wealth indicators	No response	Total
Frequency	52	15	4	9	80

Table S2/38: Type of Water Storage Container.

Material	Plastic	Metal	Earthenware	Total
Frequency	17	59	1	77*

* 3 Missing cases.

Table S2/39: Is the Water Storage Container Covered?.

Response	No	Yes	No Response	Total
Frequency	43	36	1	80

Table S2/40: Are the Water Storage and Collection Containers the Same.

Response	No	Yes	No Response	Total
Frequency	4	74	2	80

Table S2/41: Capacity of Water Storage Container.

Capacity of Container	5 Liters	10 Liters	15 Liters	20 Liters	20+ Liters	TOTAL
Frequency	10	14	13	40	2	79*

* 1 Missing case.

Table S2/42: Do Animals go into the Kitchen.

Response	No animals	No	Yes	Total
Frequency	19	33	26	78*

* 2 Missing cases.

Table S2/43: Drainage of Plate Drying Rack.

Response	No Plate Drying Rack	Good Drainage	Bad Drainage	Total
Frequency	10	34	35	79*

* 1 Missing case.

Table S2/44: Location of Plate Drying Rack.

Response	No Plate Drying Rack	Good Location	Bad Location	Total
Frequency	10	23	42	75*

* 5 Missing cases.

Table S2/45: Type of Toilet.

Type of Toilet	Blair Toilet	Open Pit	Attempt-ed Blair	No Toilet	Shared Toilet	Flush Toilet	Total
Frequency	37	18	7	14	3	1	80

Table S2/46: Presence of Flies By Area.

Presence of Flies	High Number	Low Number	Unnoticable	Total
Area				
Rural	5	13	9	27
Peri-urban	0	12	14	26
Farm	10	11	6	27
Total	15	36	29	80

Table S2/47: Animals Kept By Family.

Animal	No	Yes	Total
Any Animal At All	22	58	80
Dogs	52	28	80
Goat	79	1	80
Chickens	32	48	80
Cats	76	4	80
Rabbits	67	13	80
Ducks	78	2	80
Other Animals	79	1	80

Table S2/48: Family Sources of Income.

Income Source	No	Yes	Total
Sale of Vegetables	44	36	80
Tenants	74	6	80
Salaried Worker	45	35	80
Domestic Worker	75	5	80
Casual Worker	70	10	80
Two or More Casuual Workers	79	1	80
Farm Labourer	53	27	80
Wife Works on Farm	78	2	80
Self Employed	70	10	80
Traditional Healer or Health Worker	76	4	80
Sale of Chickens or Other Animals	77	3	80
Money from Sons or an Inheritance	74	6	80

Annex A3:

The Individual and the Family Microbiological Indices

1. Their Purpose.

The function of the indices is to overcome some of the limitations associated with microbiological data. The first of these is the high variability associated with the raw counts. For example TC1 and TS1 have means of 56 and 136 respectively and standard deviations of 136 and 337 respectively. Another limitation is that the microbiological device of calling very high bacteria counts "Too Numerous To Count" (TNTC) means that information is lost. For the purposes of this study all TNTC scores were recoded as 1,000. Finally the indices have convenient statistical properties, namely that the values of the index are normally distributed.

2. Data Sources.

The index is based on the TC1 and TS1 counts only. The reason for this is that this data is considered the best indicator of the number of bacteria present on people's hands. It was the most extensively collected data, 274 different people were sampled, and was collected over the longest period of time, October 1987 to January 1988. This meant that it was a significantly more reliable data source than either of SC1 and SS1 or MC1 and MS1.

3. Reasons for Taking the Natural Logarithm of the Data.

The natural logarithms of TC1 and TS1 were taken for two reasons. The first is microbiological and the second is statistical. From a microbiological point of view a bacteria count of 200 would be considered closer to a count of 700 than to a count of 10, even though numerically the reverse is true. However if logs are taken the counts become 5.3, 6.6 and 2.3 respectively, which is in line with the microbiological interpretation. From the statistical viewpoint the counts recorded can be regarded as the true counts plus an error term, as there is usually some experimental error associated with counting the bacteria colonies on a petri-dish. For the purposes of some statistical techniques it is preferable if this error term satisfies certain statistical criteria. The most important of these is that the variances of the error terms are equal (heteroscedasticity). Since larger counting errors are associated with larger counts it was considered likely that the standard deviation of the error term was proportional to the mean of the recorded counts.. Hence a logarithmic transformation was used to enforce heteroscedasticity.

4. Reason for adding logged scores.

In order to add two entities together and not end up with a meaningless number (for example 2 US$ + 5 Z$ = 7 is meaningless) certain conditions need to be met. The first is that the quantities of interest measure the same basic phenomena. In the case of this study the phenomena of interest is faecal contamination of the hands. Faecal coliform and faecal streptococci counts certainly on their own are measures of this contamination but it still remains to be shown that the addition of their scores is a meaningful measure. The Pearson Correlation coefficient of the logged scores of TC1 and TS1 was 0.313 which indicated that significant positive correlation at 99.9% probability, and provides the justification of adding the logged counts together.

5. Reason for taking Z-Scores.

Taking the Z-score of a set of data simply means transforming the data so that it has a mean of 0 and a variance of 1. The reason for doing this was that the faecal streptococci counts were on average much higher than the faecal coliform counts and this would unduly influence the added scores in favour of high faecal streptococci counts. However it was considered appropriate to give both faecal coliform and faecal streptococci counts equal weight because both were considered equally good indicators of faecal contamination, hence their standardization through the Z-scores.
Only after the Z-scores had been taken was the data from faecal coliform and faecal streptococci added together and this resulting number was the Individual Microbiological Index (IMI).

6. Family Microbiological Index.

The FMI was calculated by averaging the IMIs over a family and then taking the Z-scores of all these averages. It can be interpreted as a measure of the faecal contamination prevalent in a family. It is worthwhile deriving an index at the family level because this is the simplest unit above the individual that can be efficiently targeted with health information. The idea is that a family could be identified as high risk through the FMI and education could be directed at the family through a key individual, notably the mother.

7. Interpretation of the FMI

Since the FMI is a standardized score, positive values are associated with above average levels of faecal contamination and negative values with below average levels of contamination. A mean score of the FMI for a particular subset of a community of 0.5 would be interpreted by saying "this subset lies on average around the 70th centile on a scale of faecal contamination", where the 70 is obtained by looking up the value of 0.5 in normal distribution tables. The value of the FMI is of course no measure of the prevalence of diseases transmitted by bad hygiene, but the underlying assumption of all of this study is that poor hygiene reflected through high faecal contamination is positively correlated with higher incidence of disease.

8. Bar Charts.

Charts S3/C1 to S3/C4 show the effects of the transformations on the raw data.

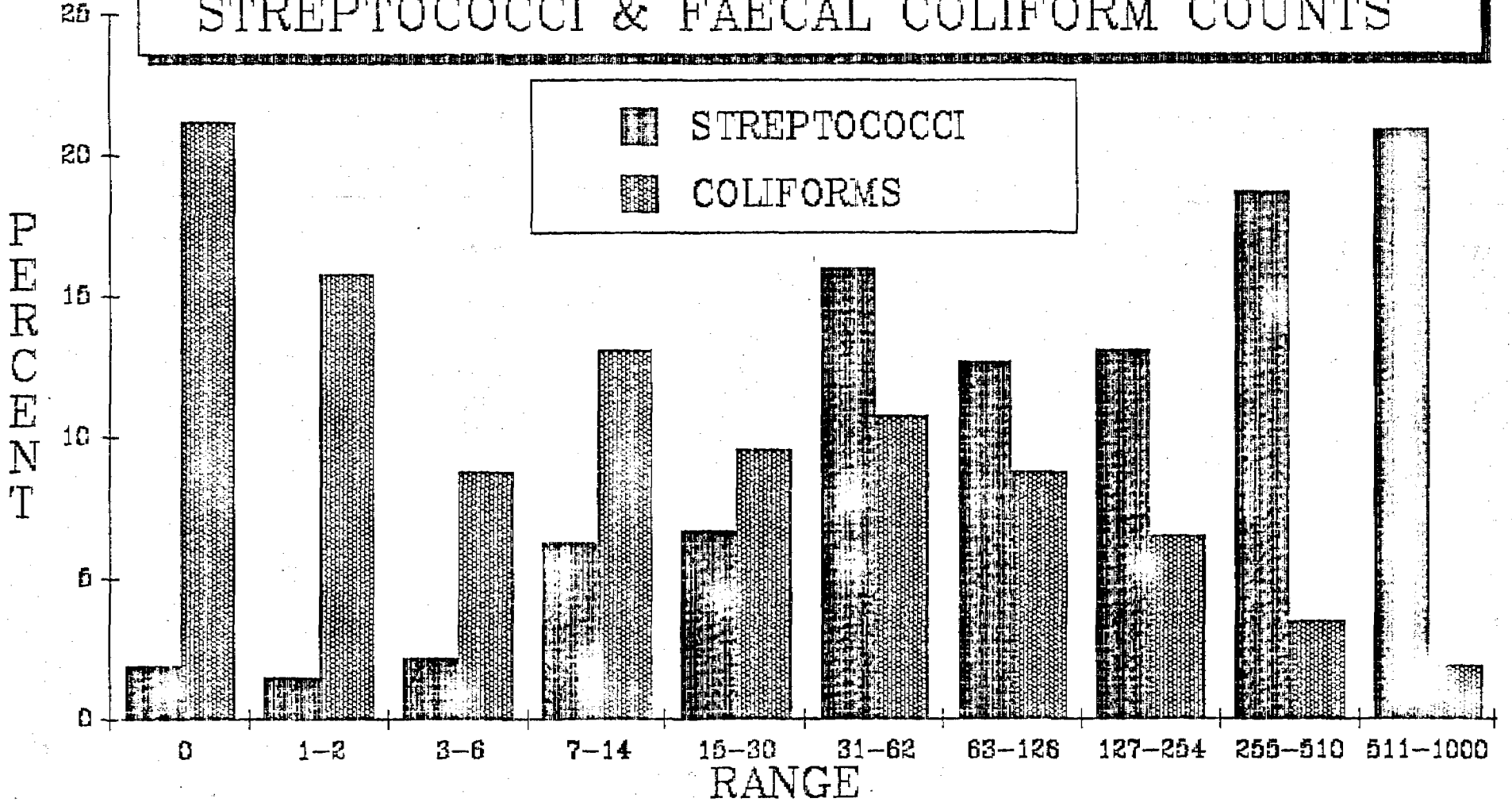
Chart S3/C1 shows the distributions of the faecal coliform and faecal streptococci counts. Note that a Log scale has been used on the X-axis.

Chart S3/C2 shows the distributions for the Z-scores of the logged faecal coliform and faecal streptococci counts.

Chart S3/C3 shows the distribution of the IMI.

Chart S3/C4 shows the distribution of the FMI.

CHART S3/C1: DISTRIBUTION OF FAECAL STREPTOCOCCI & FAECAL COLIFORM COUNTS



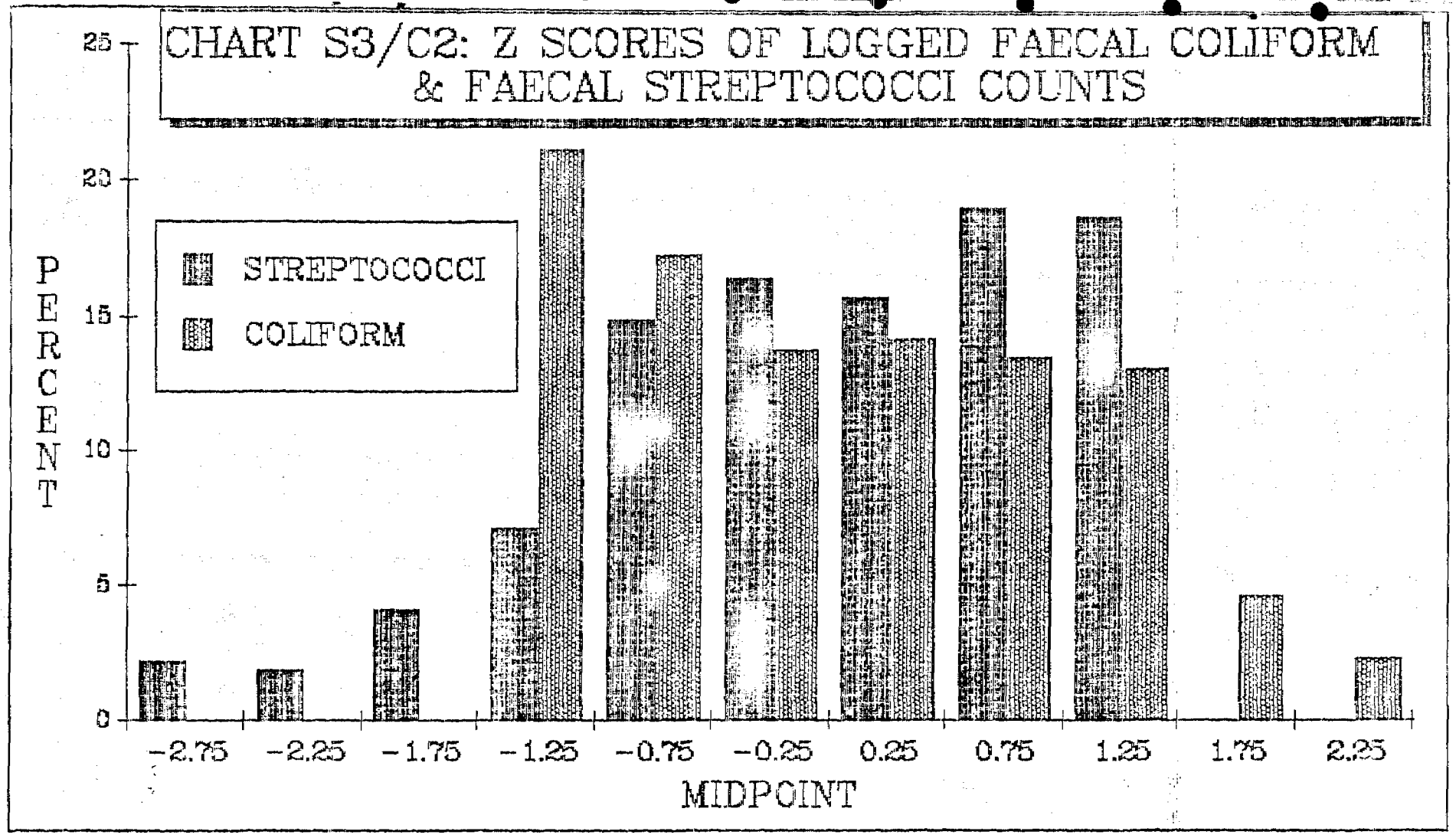


CHART S3/C2: Z SCORES OF LOGGED FAECAL COLIFORM & FAECAL STREPTOCOCCI COUNTS
STREPTOCOCCI
COLIFORM
PERCENT
25
20
15
10
5
0
-2.75
-2.25
-1.75
-1.25
-0.75
-0.25
0.25
0.75
1.25
1.75
2.25
MIDPOINT

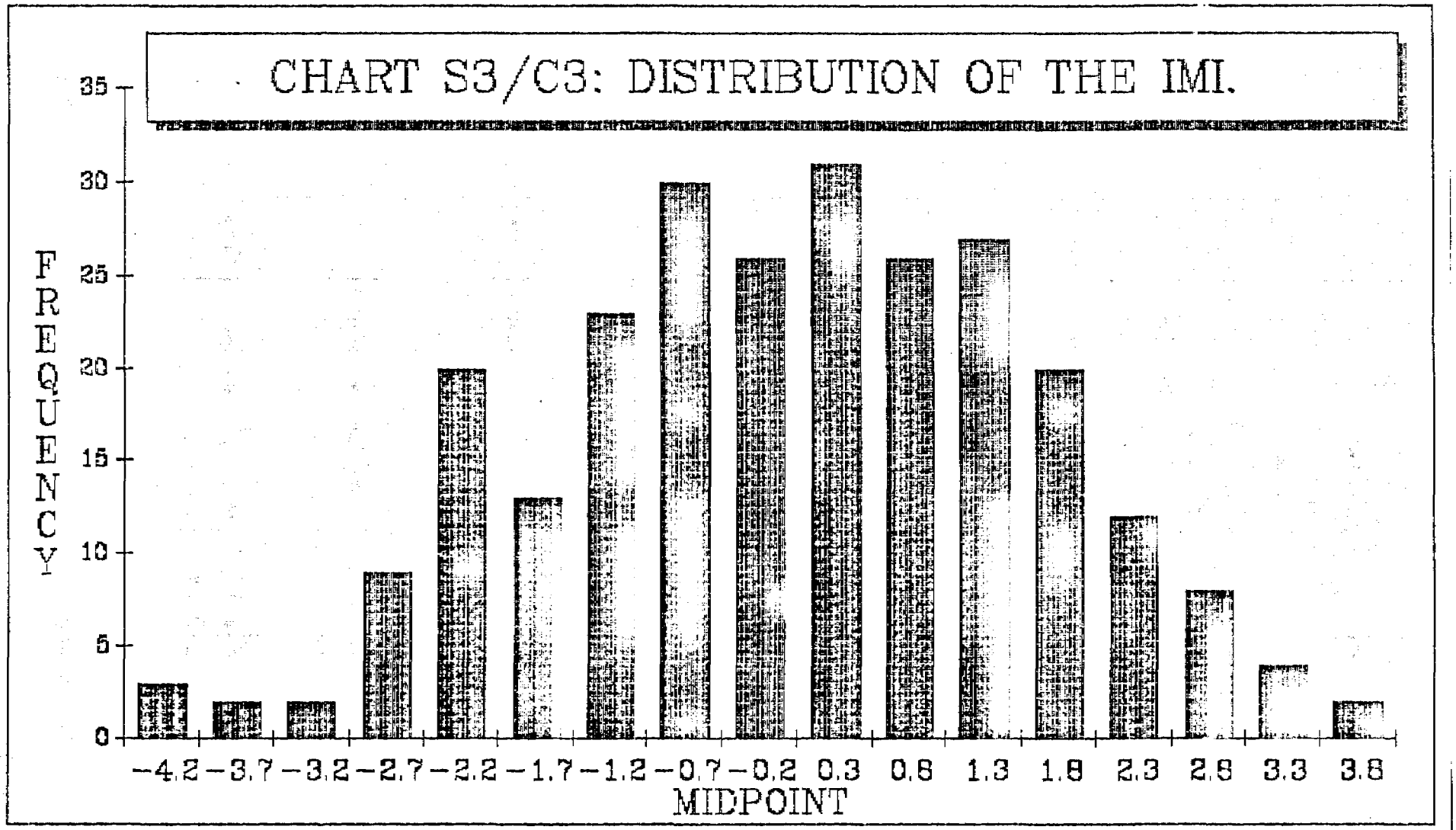
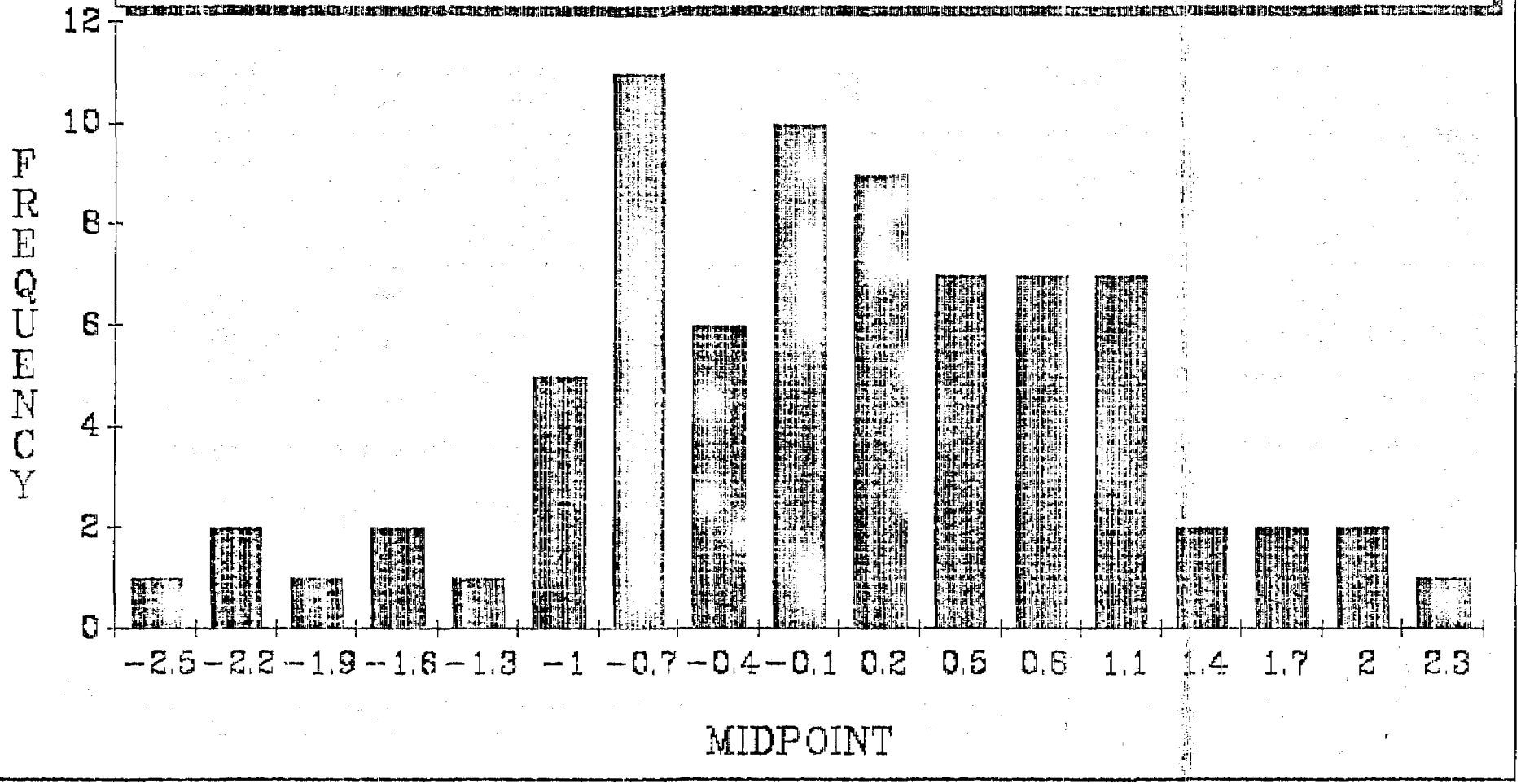


CHART S3/C3: DISTRIBUTION OF THE IMI.
FREQUENCY
35
30
25
20
15
10
5
0
-4.2 -3.7 -3.2 -2.7 -2.2 -1.7 -1.2 -0.7 -0.2 0.3 0.8 1.3 1.8 2.3 2.8 3.3 3.8
MIDPOINT

CHART S3/C4: DISTRIBUTION OF THE FMI.



Annex A4: Results of the Mukombe Questionnaire.

Table of contents. Page Number.

S4/1 Frequency of Response by Area.

Area	Peri-urban	Farm	Rural	Total
Frequency	16	16	15	47

S4/2 Is the Mukombe Hung Up by Is There Water In It.

		Is It Hung Up	
		No	Yes
Is There Water In It	No	2	9
	Yes	0	34

S4/3 Changes in Appearance.

Change in Appearance	Frequency
Soap added to it.	2
Mended.	3
Outlet enlarged.	1
Broken spout/rusted.	2
Painted.	2

S4/4 Signs of Use.

Signs of Use	Frequency
Water beneath Mukombe.	13
Mukombe full of water.	25
Healthy flowers underneath.	2
String changed.	1
No signs of use.	19

S4/5 Is the Mukombe being used by Area.?

Area	Peri-urban	Farm	Rural	Total
Used	7	10	12	29
Not Used	9	5	3	17

S4/6 Who Fills the Mukombe.

Who Fills	Mother	Daughter	More than 1 person	No-one specific	No-one at all	Other
Frequency	12	3	22	1	1	4

S4/7 How Often is it Filled.

How often is it filled.	1 per day	2 per day	More than 2 per day	Once every 2 days	Less than every 2 days	Never filled	Other
N.	10	14	2	8	7	1	1

S4/8 Who Uses the Mukombe.

Who uses it	All adults	Some adults	All children	Children over a certain age	Nobody
Frequency	40	1	32	6	1

S4/9 Why is the Mukombe Liked?

Reason	It is convenient	It is hygienic	It reminds us to wash our hands	It cleans hands	Don't have to fetch a dish
Frequency	15	9	1	15	5

S4/10 When is the Mukombe used?

Times of Usage	Frequency
After using the toilet.	42
Before food preparation.	2
After changing nappies.	3
After meals.	1
After gardening.	9
When hands are dirty.	4
On getting up.	4
After school.	1
Never	1

S4/11 Is the Mukombe used for drinking?

	Not Used	Used
Frequency	42	1

S4/12 Is the Location OK?

	Location Liked	Mukombe was Moved
Frequency	41	2

S4/13 What did the Neighbours say?.

	No Comment	Liked the Mukombe
Frequency	10	33

S4/14 Suggested Improvements

Improvement	Frequency
Put a handle on it.	3
Use stronger string.	2
Put a lid on it.	4
Make a larger outlet.	5
Paint the Mukombe.	1
Provide soap and a towel.	1
Add "Surf" to the water.	1
Use wire instead of string.	3
Extend length of string.	1

S4/15 Statistics on amount willing to pay, and the cutoff point in Z$.

Statistic	Median	Mean	Mode
Prepared to Pay	4.25	5.27	5.00
Cutoff Point	5.25	7.02	2.00

Media Formulae

Membrane Lauryl Sulphate Broth (Oxoid)

(grams per litre)

Bacteriological peptone	39.0
Yeast extract	6.0
Lactose	30.0
Phenol red	0.2
Sodium lauryl sulphate	1.0

pH 7.4

Slanetz and Bartley Media (Oxoid)

(per litre)

Tryptose (Oxoid L47)	20.0
Yeast extract (Oxoid L21)	5.0
Dextrose	2.0
Disodium hydrogen Phosphate	4.0
Sodium azide	0.4
Tetrazolium chloride	0.1
Agar no.1 (Oxoid L11)	10.0

pH 7.2 (approx.)